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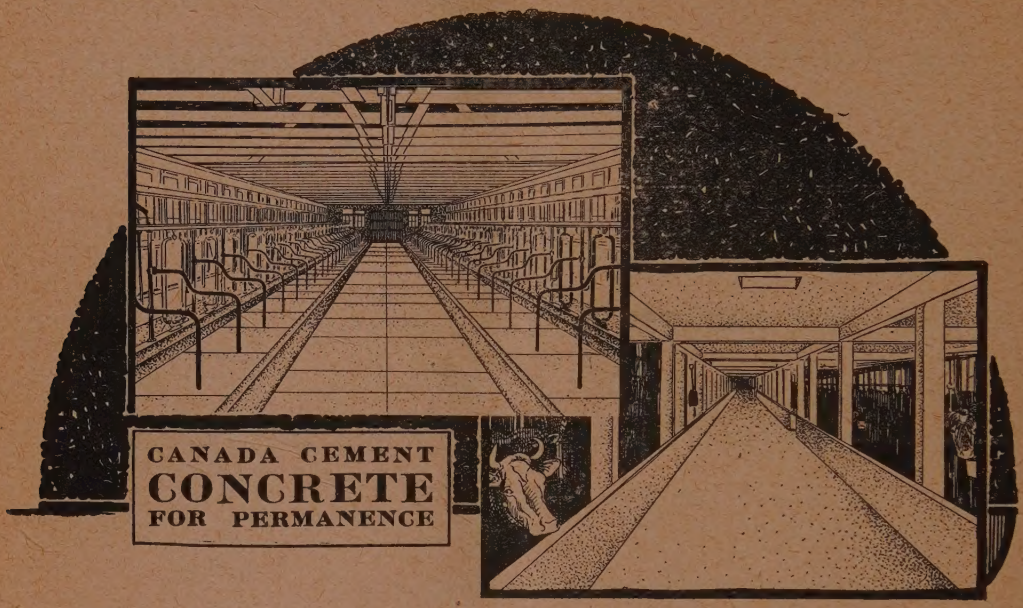

Concrete in the Dairy Barn

The dairy cow may be compared with a machine in that she is a complicated mechanism which turns raw materials such as grain, and other food, into the finished products, milk and butter fat. The more efficiently a machine works, the more is its earning capacity assured. If the dairy cow can be kept in good productive condition, more dollars go into the dairyman's bank account.

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Inheritance of Milk Production.*

JOHN W. GOWEN

Agricultural Experiment Station, Orono, Me.

For the great classes of agricultural animals, cattle, horses, sheep, hogs, and to some extent poultry, man has evolved methods by which an animal and its parents may be recorded. These registries present the great problem which confronts the breeder of today, namely: How shall he best breed his animals for production? Despite the occasional notable success which has been attained in this direction it remains a fact that up to the present our knowledge in this field has been too largely of a somewhat haphazard and empirical character. To the dairyman it is an obvious fact that some cows which are great producers, perhaps nearly as great as we shall ever see, have been bred. But if one tries to breed more like these he too often meets with failure where he hoped to succeed. Even though one studies most carefully the pedigrees of a great producer and attempts to repeat as nearly as possible the same kind of breeding, he usually does not get his desired result. The reason of course is that there are factors involved in the breeding of the great producer which he overlooks, because he does not understand them to be of importance. If one attempts to learn from the breeder of a great dairy cow how she was produced or how a great milking strain was bred he will in practically every case find that the breeder either cannot or will not give him the kind of information which will make it possible for him to go out and do the same thing. Further, if one attempts to learn from the published pedigrees in regard to this matter the outcome is that different men draw different conclusions as to what is the factor of primary importance in a given pedigree.

The real fact is that in the late state of our knowledge regarding inheritance and inbreeding nobody could tell for most animals and particularly for dairy cattle, what were the facts of real significance and importance as distinct from those which were trivial and accidental in a pedigree. Pedigrees are the ultimate foundation of all breeding operations, but before we can reach the condition where the results of breeding will be certain and sure, we must learn how to separate the wheat from the chaff in pedigrees. No one who has studied the breeding of dairy cattle doubts that much in the pedigree of any of the great performers has no real significance whatever in the attainment of that performing ability. But how shall we know what is of real importance in a pedigree, and what can without harm or loss be neglected as of no significance? If breeding for dairy production is to be put on the sure basis of exact scientific knowledge so that the farmer will not be forced from necessity to try costly and doubtful experiments for himself, but instead can breed his cattle with the assurance of good results provided he feeds and houses them decently, then we must have thorough and systematic studies of the inheritance of dairy qualities.

To obtain a perspective and an objective view of the problem of the inheritance of milk production in dairy cattle I have chosen to present the available information in the form of a study of the pedigree and the weight to be attached to the facts which may be derived from a study of each animal in it.

The systems used in herd registers are quite diverse. Those used for the recording of dairy cattle appear to be adequate and quite satisfactory when used in pedigree tracing. In their barest outlines they consist of recording the name and number of the offspring and the name and number of the sire and dam. Males and females are recorded separately. Each animal is given a distinctive name and number. All records are arranged numerically. They are not satisfactory for tracing the progeny of any given animal. The system as a whole is, however, so much better than that devised by man for recording his own ancestry that there is little room for complaint.

*Paper given at the Fourth Annual Convention, C.S.T.A., June, 1924.

As practiced today the basis of registration of an animal lies in establishing the following points. First that the sire and dam of the animal were properly registered in the breed; second that the dates of service and birth are mutually compatible with the known facts about gestation and the sire and dam; and third that the characteristics of the animal (coat color, etc.) are those of the breed. The details of the individual blanks vary with the requirements of the different breed offices.

The Pedigree.

A pedigree properly built up is a record of ancestry, of possible or probable prepotency, of inbreeding and relationships. It will nowadays show records of performance and frequently records of type. It gives a picture of the lines of descent and shows the famous ancestors to which the individual traces. The pedigree of the Holstein-Friesian bull, Baron Netherland DeKol, 28373, is shown below.

The pedigree of Baron Netherland DeKol is of four generations showing the ancestry only, the records of production, type and show winnings not appearing. This pedigree could be extended much further, of course. The making of such a pedigree is quite simple. The number 28373 is looked up in the Holstein-Friesian herd book under bulls. The name is checked as Baron Netherland Dekol. The record then shows Baron Netherland DeKol's sire as Lord Netherland DeKol 22187 and his dam as Susie DeKol's Countess 44906. The sire, 22187, is next looked up under bulls and the dam, 44906, under cows, obtaining the grandparents. The repetition of this process completes the pedigree. The pedigree is of four generations. It is not extended further because such a length of pedigree gives us most of the important points which may be utilized in determining what may be expected of the animal.

Information Given by a Pedigree.

It is to be noted first that the granddam on the paternal and maternal side is the same animal, Susie DeKol 33688. In the third generation we find Netherland DeKol 10605 appearing in the sire's side and in the dam's side of the pedigree. In the fourth genera-

28373 Baron Netherland DeKol ♂	22187 Lord Netherland DeKol ♂	17713 ♂ Netherland DeKol's Perfection	10625 ♂ Pietertje 2d's Koningin	3515 Koningin van Friesland 5th's Netherland ♂
				3273 HHB ♀ Pietertje 2d
			10605 ♀ Netherland DeKol	4584 HHB ♂ Netherland Alban
				734 ♀ DeKol 2d.
		33688 ♀ Susie DeKol	11584 ♂ DeKol 2d's Netherland	4584 HHB ♂ Netherland Alban
				734 ♀ DeKol 2d
			20201 ♀ Daisy DeKol	2767 ♂ DeKol 2d's Prince
				2422 ♀ Belle Barnum
	44906 ♀ Susie DeKol's Countess	21171 ♂ Count Mechthilde DeKol	19056 ♂ Sir Abbekerk	16469 ♂ Tirania's Sir Mechthilde
				12702 ♀ Alberta Abbekerk 2d
			10605 ♀ Netherland DeKol	4584 H.H.B ♂ Netherland Alban
				734 ♀ DeKol 2d
		33688 ♀ Susie DeKol	11584 ♂ DeKol 2d's Netherland	4584 H.H.B ♂ Netherland Alban
				734 ♀ DeKol 2d.
			20201 ♀ Daisy DeKol	2767 ♂ DeKol 2d's Prince
				2422 ♀ Belle Barnum

tion we find Netherland Alban 4584 and DeKol 2d 734 appearing twice on the sire's side of the pedigree. The second appearance of these animals is noted by the solid circles in the space containing their names. The open circles with the crosses indicate that the animals are repeated due to the repetition of those noted in the sentence just above.

Baron Netherland DeKol is consequently quite highly inbred, the inbreeding partaking of the nature of relationship between the sire and dam. In the sire's side of the pedigree we find that the sire himself is inbred, the animals Netherland Alban and DeKol 2d being repeated in his pedigree. In terms of inbreeding we find that Baron Netherland DeKol is inbred to 25% in the second generation, 37½% in the third generation, and 50% in the fourth generation. If we calculate the total amount of inbreeding we find that for these four generations there is over 50% as much inbreeding as that found for brother and sister matings (Pearl 1). Baron Netherland DeKol further displays the fact that his parents were related. On a percentage basis this relationship equals 50% in the second generation, 75% in the third generation, and 75% in the fourth generation. From the standpoint of pedigree study these facts indicate that we are dealing with a highly inbred bull whose parents are closely related. The question which must now be taken up is the influence of inbreeding or relationship on the milk yield and butter-fat percentage of the progeny of such animals.

Effect of Inbreeding on Milk Yield and Butter-fat Percentage.

Pedigree study then gives us the amount of inbreeding which has taken place in the ancestry of any animal. The point which we wish to know is the effect of this inbreeding on milk yield and butter-fat percentage. In the studies of this laboratory on the Jersey and Holstein-Friesian breed it has been found that the inbreeding of all cattle in these breeds is relatively small in amount, taking them as an average (2, 3, 4). It has further been found that this small amount of inbreeding has no appreciable effect on milk yield and butter-fat percentage, the highest group of producing cows in the breed showing practically the same amount of inbreeding as does the lowest producing group. Not only that but the rate of inbreeding in the different groups is the same. You are as likely to find a high producing cow with a high amount of inbreeding as you are to find a low producing cow with the same amount of inbreeding. We may conclude therefore that the study of the pedigree for the inbreeding it contains, indicates little as to the actual milking qualities of the cow pedigreed.

There is one other point to be taken into consideration in purchasing an animal for breeding purposes which need not be taken into consideration in purchasing an animal for its productive ability. Most inbreeding experiments show that the inbreeding of an animal is an indication of that animal's probable prepotency. If the inbreeding is large in amount that animal will probably reproduce its characters in its offsprings to a higher degree than will the animal whose inbreeding is of lesser amount. Probably the most noted illustration of this point is that furnished by the Bates Dutchess cattle. Wright (5) has recently analyzed the inbreeding and relationship existing in these cattle showing that the inbreeding was quite high in amount and that the resulting prepotency of these animals would consequently be likely to be large in amount as their inbreeding would be expected to concentrate desirable inheritance in this strain. The historically notable results attained by the use of these Dutchess cattle indicate that in actual breeding practice this strain of cattle was preeminently prepotent when outcrossed as would be expected from the results of a study of the inbreeding in this family.

Other results also tend to accompany inbreeding unless the breeder is very skillful in his selection to avoid them. The most important of these is reduced fertility in the individual which is highly inbred. A reduction in vigor is also often one of the accompanying effects of inbreeding. This result does not hold the same importance to the reduction in fertility, since it is possible, by the external appearance of the animal, to determine any reduction in vigor which may have taken place through inbreeding whereas it is not possible to determine the reduction in fertility by the external appearance. All these detrimental results may be avoided by careful selection, however.

Famous Animals Found in a Pedigree and their Relation to Milk Yield.

Famous animals obtain their prominence in a variety of ways. These methods include: advertising, records of merit, either in milk yield or butter-fat percentage; type as shown by show-ring winning; and nowadays by the number of times that animals are found in the pedigrees of cows whose production in milk yield or butter-fat percentage is phenomenal.

If we turn back to the pedigree of Baron Netherland DeKol it will be noted that it is possible to determine from such a pedigree, the animals whose progeny or owners have made them famous and consequently have enhanced the value of the animal whose pedigree is being studied. The greater the number of generations through which a pedigree is traced, the greater the possibilities of finding these famous ancestors. This is because of the fact that the chances of finding any important animals are increased considerably by the widening number of ancestors for each generation traced and by the relative decrease in number of possible ancestors due to the small number of importations of cattle into this country. Thus in the four generation pedigree of Baron Netherland DeKol we note Netherland DeKol in the third generation,—a cow which appears very frequently in the Holstein-Friesian pedigrees. DeKol 2d's Netherland is another sire that is found in many pedigrees. DeKol 2d appears more frequently than any other animal in a four generation pedigree. The list of famous animals found in the pedigree of Baron Netherland DeKol could be much extended.

The illustration has made the problem evident however. What is the significance of these animals to the probable milk yield of the cow which is pedigreed? Stated otherwise the question becomes, is an animal whose pedigree shows a large number of famous ancestors more valuable or more likely to produce a high quantity of milk or butter-fat than an animal whose pedigree does not contain so many of these famous ancestors? The results of extended studies on the Jersey and Holstein-Friesian breeds (2, 3, 4,) have shown that the pedigrees of high producing animals or low producing animals or pedigrees of a random sample of the breed all contain animals which have been famous in the breed's development. In other words the mere presence in a pedigree of such a famous animal is no guarantee of the worth of the animal pedigreed.

The appearance of these famous animals in the pedigree has also been studied. In general it was found that animals which had Advanced Registry records have slightly more of these famous ancestors than the animals which did not have these Advanced Registry records. No difference in the average amount of milk produced by the Advanced Registry cows could, however, be noticed as the number of famous ancestors found in the pedigree was varied. These results seem to indicate that the presence of famous animals within a pedigree is but little indication of the possible productive worth of the animal so pedigreed. This conclusion may seem rather strange until it is realized that generally the famous animals are in point of fact quite distantly removed in number of generations from the animals whose milk production we are trying to determine. Thus while the famous ancestors undoubtedly in the majority of cases obtained their fame by their productive worth, they are so far removed from the animal which is pedigreed that their influence or chance of transmitting to it desirable characters for milk yield and butter-fat percentage is very small. This deduction also follows for the breeders' method of estimating the amount of blood of a given ancestor which an animal contains. Thus if the ancestor is a sire he considers the offspring as 50 per cent of the sire's blood; if it is a grandparent he considers the offspring 25 per cent ; if it is a great-grandparent 12½ per cent ; if it is a great-great-grandparent 6¼ per cent. It does not take long for one to see that the influence of any ancestor must be proportional to the number of generations they are away from the animal pedigreed. As the ancestors of note in any pedigree are generally at least great-grandparents and often even further removed it is at once clear that famous ancestors should in general have little effect in predicting the relative productivity of an animal pedigreed. Thus the conclusion derived from the study of the actual results agrees with common sense result showing that famous ancestors are on the whole a poor means of predicting the productive worth of an animal. We have thus exhausted any hope of results which may be derived from the study of pedigrees as such. It is necessary now to turn to the further elaboration of the pedigree known as the pedigree with performance records. For this purpose we take the pedigree as published in Holstein-Friesian Foundations, (6) of the cow Molly Veeman Segis Pontiac No. 283159.

OLLY VEEMAN SEGIS PONTIAC
No. 283159

Completed record March 5, 1922.

ecord made at 6y 5m 3d.	1273.99
ilk	28488.20
verage % fat	3.58
utter 7 days	36.11
ilk	718.10
ecord made at 5y 3m 13d.	32.48
ilk	608.60
utter 30 days	119.27
ilk	2789.40
utter 365 days	896.80
ilk	22979.90
ecord made at 2y 4m 4d	28.61
ilk	502.00
utter 30 days	107.47
ilk	1949.00

1 A.R.O. daughter.
1 A.R.S.O. daughter.
1 proven son.
King Homestead Pontiac Veeman
Another son Grand Champion,
ichigan State Fair, 1923.

SIRE:

KING SEGIS PONTIAC COUNT 93909
37 A.R.O. daughters.
5 above 35 lb.
9 others above 30 lb.
12 from 20 to 29.24 lb.
7 above 700 lb. milk.
26 A.R.S.O. daughters.
11 from 1000 to 1287 lb.
Sire of: (year records)
Princess Changeling Segis
.....1287.56
Milk 31063.30
Molly Veeman Segis Pontiac—
Butter 365 days 1273.99
Milk 28488.20
Beauty Beets Walker Segis—
Butter 365 days 5y ... 1230.34
Milk 30814.00
Butter 365 days 4½y.. 1021.63
Milk 27175.60
Butter 365 days 2½y.. 1040.64
Milk 25343.30
Silver Bow Pontiac Segis—
Butter 365 days 1212.98
Milk 30009.40
Jewel Pontiac Segis 3½y 1171.15
Milk 27068.50
(World's record when made)
Butter 365 days, 26m.. 1004.25
Milk 21891.80
Beauty Girl Pontiac Segis
3y 1112.91
Milk 24924.70

DAM:

MOLLY VEEMAN ARTIS 2d 182421
Butter 7 days at 4½y .. 18.25
Milk 381.70
Butter 7 days at 3½y . 13.94
Milk 303.90
1 A.R.O. daughter—
Mollie Veeman Segis Pontiac
Butter 365 days 6y ... 1273.99
Milk 28488.20
Butter 7 days 36.11
Milk 718.10
Butter 7 days 5y 32.48
Milk 608.60
Butter 30 days 119.27
Milk 2789.40

KING SEGIS PONTIAC 44444
194 A.R.O. daughters.
8 from 30 to 37.56 lb.
51 from 20 to 29 lb.
23 A.R.S.O. daughters.
2 over 1000 lb.
97 proven sons.
43 30-lb. granddaughters.
16 1000-lb. granddaughters.
Sire of:
K S P Lily McKinley—
Butter 365 days 4½y .. 1199.84
Milk 24569.40
K S P. Andire 1064.59
Milk 23510.40

K P LILITH CLOTHILDE 110228
Butter 365 days at 4y .. 1043.28
Milk 22229.80
(World's milk record when made)
Butter 7 days at 5y.... 29.04
Butter 30 days 120.65
Butter 7 days 4 y 27.56
Milk 600.00
Butter 30 days 113.89
Milk 2374.50
5 proven sons.
17 30-lb. granddaughters.
Full sister to:
K P Lilith Boon 32.22
K P Lilith Lady Clothilde 28.47

KING PONTIAC ARTIS 63994
20 A.R.O. daughters.
2 with 31 and 33 lb.
11 from 20 to 27.85 lb.
5 A.R.S.O. daughters.
1 with 1018 lb.
17 proven sons.
Sire of:
Artis Pontiac Saskia ... 33.42
Milk 601.10
Butter 30 days 140.16
Milk 2706.10
Artis Pontiac Susie Judith
4½y. 31.62
Milk 632.30
Butter 365 days 1018.74

MOLLY VEEMAN ARTIS 143719
Butter 7 days at 26 m.. 12.79
Milk 223.80
2 A.R.O. daughters—
Molly Veeman Walker 3½y 21.20
Milk 403.50
Butter 7 days 4½y ... 20.21
Milk 452.30
Butter 7 days 30 m .. 13.46
Milk 317.50
Molly Veeman Artis 2d
4½y 18.25
Milk 381.70

KING SEGIS 36168
87 A.R.O. daughters.
11 from 30 to 35.56 lb.
47 from 20 to 29.1 lb.
2 A.R.S.O. daughters.
87 proven sons.
18 1000-lb. granddaughters.

PONTIAC CLOTHILDE DEKOL 2d 69991
Butter 7 days at 6½y 37.21
Milk 646.10
Butter 365 days 1271.60
Milk 25318.00
(World's butter records when made)
4 A.R.O. daughters.

KING OF THE PONTIACS 39037
283 A.R.O. daughters.
37 from 30 to 44 lb.
161 from 20 to 29 lb.
51 A.R.S.O. daughters.
5 over 1000 lb.
231 proven sons.

LILITH CLOTHILDE BOON 78841
3 A.R.O. daughters—
K P Lilith Boon 32.22
K P Lilith Clothilde 5y .. 29.04
Butter 365 days 4y 1043.28
1 28-lb. 4-year-old.
2 other A.R.S.O. daughters.

KING OF THE PONTIACS 39037
283 A.R.O. daughters.
37 from 30 to 44 lb.
161 from 20 to 29 lb.
51 A.R.S.O. daughters.
5 over 1000 lb.
231 proven sons.

PONTIAC ARTIS 61114
Butter 7 days at 6½y .. 31.71
Butter 30 days 129.44
Milk 2488.50
Butter 365 days 1076.91
Milk 21834.70
3 proven sons.

SIR KORNDYKE PONTIAC ARTIS 46301
66 A.R.O. daughters—
Ruth Pontia Veeman Korndyke 34.16
7 others over 30 lb.
32 from 20 to 29.76 lb.
6 A.R.S.O. daughters.
56 proven sons.

PLEASANT HILL MOLLY VEEMAN 100926
Butter 7 days at 8y 25.38
Milk 551.80
Butter 30 days 100.15
4 A.R.O. daughters
1 22-lb. 4-year-old
1 proven son.

MERCEDES JULIP'S PIETERTJE'S PAUL 29830
90 A. R. O. daughters
3 from 30 to 38.36 lbs.
40 proven sons.

A. & G. INKA MCKINLEY 55163
Butter 7 days at 9½y. 29.62
Milk 661.10
4 A.R.O. dghtrs. from 20 to 28.89 lb.

PONTIAC KORNDYKE 25982
151 A.R.O. daughters.
18 from 30 to 42.1 lb.
4 1000-lb. daughters.

PONTIAC CLOTHILDE DEKOL 49657
Butter 7 days at 6 y..... 23.11
2 A.R.O. dghtrs. with 31 & 37 lb.

PONTIAC KORNDYKE 25982
151 A.R.O. daughters.
18 from 30 to 42.1 lb.
4 1000-lb. daughters.

PONTIAC LUNDE HENGERVELD 51585
Butter 7 days at 5 y..... 28.41
Milk 559.80
1 A.R.O. daughter.

LILITH PAULINE DE KOL'S COUNT 28430
98 A.R.O. daughters.
4 from 30 to 33.6 lb.
1 1000-lb. daughter.

CLOTHILDE PIETERTJE BOON 61391
1 A. R. O. daughter .. ..
Zada D. K. Count...24 m .. 12.29
Milk 247.10

PONTIAC KORNDYKE 25982
151 A.R.O. daughters.
18 from 30 to 42.1 lb.
4 1000-lb. daughters.
PONTIAC LUNDE HENGERVELD 51585
Butter 7 days at 5 y..... 28.41
Milk 559.80
1 A.R.O. daughter.

HENGERVELD DE KOL 28102
116 A.R.O. daughters.
10 from 30 to 33.6 lb.
67 proven sons.

PONTIAC CLOTHILDE INKA 44452
Butter 7 days at 9 y..... 20.36
Milk 392.80
4 A. R. O. daughters.

SIR KORNDYKE MANOR DEKOL 28133
51 A.R.O. daughters.
4 from 30 to 35 lb.
19 from 20. to 28.7 lb.

PONTIAC ARTIS 61114
Butter 7 days at 6½y. .. 31.71
Butter 365 days 1076.91
Milk 21834.70

SIR VEEMAN HENGERVELD 36158
139 A.R.O. daughters.
21 from 30 to 37 lb.
16 A.R.S.O. daughters.

ZELLA BERYL 73128
Butter 7 days at 4½y 17.48
Milk 483.50

It will be noted that the pedigree of Molly Veeman Segis Pontiac contains all the information which is given for Baron Netherland DeKol plus the records of performance for the animals contained in the pedigree. From these data it is possible to obtain inbreeding and relationship coefficients, and any famous ancestors which occur in the pedigree of this animal plus the information as to the performance in milk production and butter-fat percentage or the progeny performance for milk production and butter-fat percentage. The animal is a phenomenal cow, chosen particularly because her pedigree does fulfil most of the conditions of an excellent production pedigree. The animal herself has 7-day and 365-day records of a very high degree of merit when contrasted with those of the rest of the breed. She contains much of the Pontiac blood being inbred to King of the Pontiacs, Pontiac Korndyke and Pontiac Artis. Study of this pedigree shows that most of the animals have excellent records themselves or that their progeny have records of merit.

The question may be asked as to what is shown by such performance records? Do we know anything more about what a given individual is likely to produce or what her offspring are likely to produce, if we know the Advanced Registry performance records in the pedigrees of such animals? In other words have we any information which will enable us to interpret such performance records in terms of heredity so that we will be able to predict with any degree of certainty what the performance of an animal so pedigreed will be when it comes to milk production or to official Advanced Registry testing? This question is a question on which the Maine Agricultural Experiment Station has been working for the last ten years and on which we have today the greatest accumulation of evidence which has yet to be presented to the breeders of dairy cattle. It is to this evidence that we will now turn in trying to lay a foundation on which we can interpret the worth of a pedigree in terms of future milk production.

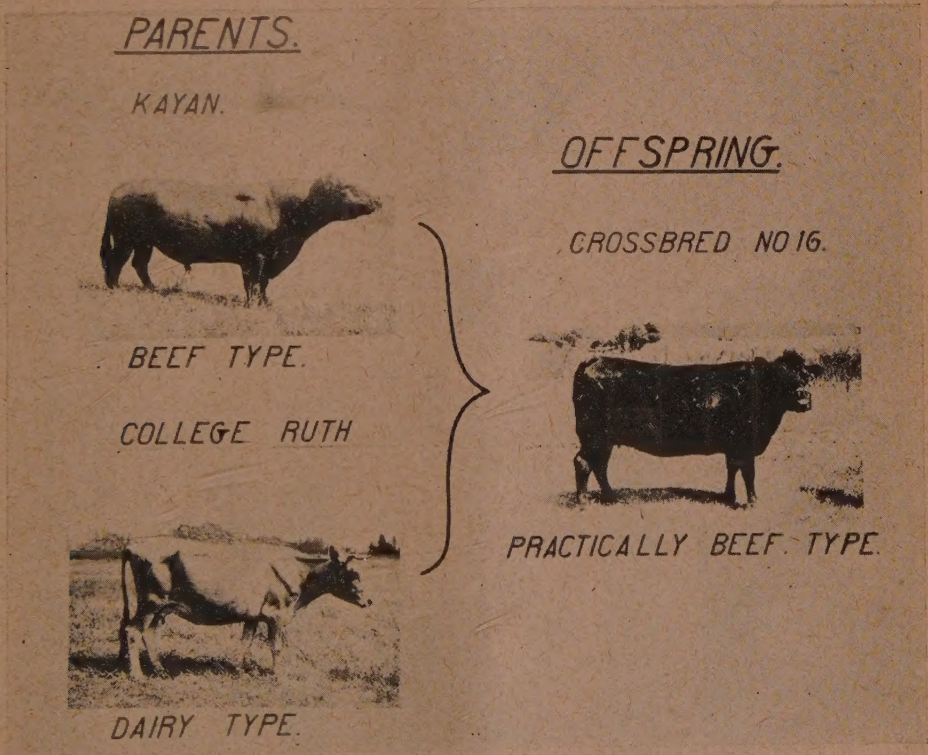
In attempting to answer this problem the first question we might ask is whether or not an animal with a pedigree is better than the grade whose parents are condemned to oblivion due to the lack of any registry system for such animals. The answer to this question was indicated many years ago by the work of such men as Van Norman, Eckles, and others in this country as well as by much similar information collected especially in Denmark in connection with Cow Test Associations. The problem has, however, been brought particularly to the fore in the last nine years, by the interesting experiments reported by Kildee and McCandlish (7), by Olsen and Biggar (8), by Lawritson, Hendrickson, and Nevens (9), and Hayden (10). These experiments point to the conclusion that in the breeding of purebred dairy bulls to unpedigreed cows there results an increase in milk yield and butter-fat in the offspring. This increase in milk yield is more pronounced for the purebred Holstein-Friesian bull and is in general accompanied by a decrease in the butter-fat percentage of offspring of such bulls. The increase in milk yield is generally not so great for the Jersey and Guernsey crosses but the fat per cent is frequently increased so that the net fat return is increased. These facts indicate a very pronounced possible increase in the milk yield and butter-fat production of unpedigreed cows by the use of purebred bulls.

It is of interest to consider somewhat critically the reasons for these results. The work initiated by Pearl (11) (the writer is responsible for the analysis of the results) and by Cole (12) in obtaining definite controlled crosses of certain levels of milk production and butter-fat percentage, together with the work done in Denmark and analyzed by Ellinger, (13) the crosses made by Bowker and analyzed by Castle (14) and Gaines (15) all point to the conclusion that progeny of parents, one of which is relatively pure for high milk yield and the other of which is relatively pure for low milk yield, have milk yields intermediate between the two parents, approaching more nearly the higher producing parent. But in crosses of high and low butter-fat percentage animals the butter-fat percentages of the resulting progeny are intermediate between the two extremes tending to approach the butter-fat percentage of the lower parent.

Purebred animals have started their existence as purebreds in relatively small communities and have been developed as purebreds separate from the other breeds. In

other words there has tended to be a concentration of inheritance in our pure breeds of cattle, or, as we may say, a concentration of prepotency for certain things has resulted in the different breeds. To take the extreme case most easily recognized by the eye, there has been such a concentration of prepotency of the beef characters in such beef breeds as the Shorthorn, Hereford, and Aberdeen-Angus, that when these animals are crossed on poorly fleshed scrub cattle there results a first generation animal carrying many of these purebreds' beef qualities. Furthermore should the cross happen to have been to a Hereford, the prepotent white face of the Hereford will also appear in the offspring.

The breeders of beef cattle have been much quicker to recognize this prepotency of the purebreds than have the breeders of dairy cattle. Thus, if we examine the census figures we find that of the beef bulls in service there are 53.4 per cent which are purebred, against 25.4 per cent of such purebred bulls in service on dairy cattle. The percentage of purebred females, while not so large, shows again that the breeders of beef cattle are more alive to the prepotency of purebred animals than are the breeders of dairy cattle. Thus, 4.1 per cent of the females in the beef breeds are purebred stock whereas only 3 per cent of the females in dairy stock are purebred. This difference in breeders of beef cattle versus those breeding dairy cattle is, I think, due to the fact that a beef man can easily see the effect of using a purebred bull on cattle used for beef purposes, whereas the effect is not so evident to the dairy cattle breeder unless he sits down and figures up his milk returns. The points for the beef animals may be illustrated by the accompanying photograph of one of the animals in our herd, Crossbred No. 16. The parents of this animal were the purebred Aberdeen-Angus sire, Kayan, and the Jersey cow, College Ruth. The beef characteristics of Crossbred No. 16 are easily noted from the photograph.



Photographs showing the prepotency of the beef characteristics in crosses of purebred beef animals. This photograph illustrates the progeny of the Aberdeen-Angus sire, Kayan, when mated to the Jersey cow, College Ruth.

The effect of using purebred Jersey sires on the ordinary mixed unpedigreed stock results in increases in milk yield which are entirely comparable with those increases in beef characteristics. These increases in milk yield often amount to as much as 100 per cent of the milk yield of the original dam. The desirability of using bulls whose pedigrees are known and which have been bred for dairy purposes for a considerable period of time is evident to anyone who cares to investigate the figures on the subject.

There is then a concentration of prepotency in our pure breeds as compared with the mixed condition found in unregistered stock. This concentration of prepotency leads to certain results on breeding these pure breeds to mixed stock exemplified by the increase in milk yield and butter-fat production of these first generation animals. These considerations show that the mere fact of an animal's holding registration papers is an indication of probable greater worth for this animal as a breeder as compared with an unrecorded animal, because it shows that a definite effort has been made in its breeding to develop certain lines of production and thus concentrate on certain prepotent effects.

We may now ask how inheritance of milk yield and butter-fat percentage takes place in registered animals with the idea of utilizing these facts in making some prediction of what the milk yield or butter-fat percentage of an animal of unkown production would be, when tested, on the basis of the known milk yield and butter-fat percentage of her parents or ancestors further removed. These facts are taken from an extensive study of inheritance as conducted by the Biological Laboratories of this Station. During the study the Rockfeller Institute for Medical Research and its directors have rendered a large amount of assistance to the continued prosecution of this work. The first problem which we take up is the problem of the relation of milk yields and butter-fat percentages of full sisters.

Milk Yields and Butter-fat Percentages of Full Sisters.

Such a comparison gives a measure of the effect of the sire and dam on the milk yield of the progeny. When contrasted with the relation of the milk yields and butter-fat percentages of half sisters, it gives us a measure of the influence of both sire and dam on the production of the progeny. The results from the comparisons of the milk yields of full sisters, half sisters with a common sire, or half sisters with a common dam are shown in Figure 1.

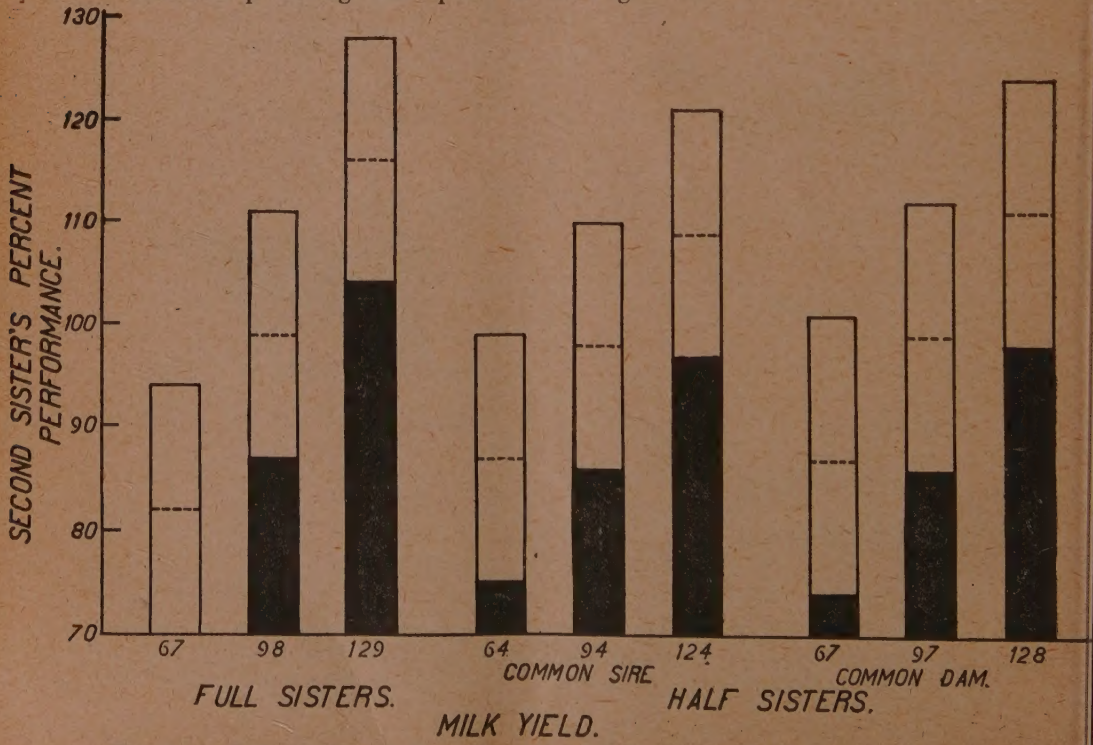


Figure. 1. Relation between the milk yields of full sisters, of half sisters with a common sire, and of half sisters with a common dam. The dotted line shows the average production, [illegible] enclosed space shows the limits necessary to include 50 out of every 100 second

This figure pictures the results as percentages of the average production of the breed. One hundred per cent represents the average production of milk over a 365-day period for the cow aged 8 years and 3 months. This average production for full sisters is 19438 pounds of milk. This production of milk in a 365-day period may seem a good deal to many dairymen who have not done Advanced Registry testing. It should be remembered, however, that the work of Eckles (17) has shown that Advanced Registry records are 1⅔ more in their production than are the records of the same cows under average good conditions. In view of this fact the dairyman is justified in dividing the Advanced Registry record by 1⅔ in comparing it with that made in his own herd under average good conditions. In the study of pedigrees and in the purchase of dairy stock these facts should be kept in mind in evaluating the worth of any animal which is so pedigreed. For comparative results, however, such records when all made in the Advanced Registry are comparable and furnish fairly satisfactory data for inheritance work.

The full sister which produces 100 per cent may be considered as producing the equivalent of the average cow or 19,438 lbs. of milk in mature form, 8 years, 3 months. Productions less than this figure are correspondingly less than the average in the percentage of milk they produce and productions more than that figure are correspondingly more than this percentage. The results may be concretely illustrated as follows. If a full sister gives 13,000 pounds of milk and the average milk production of full sisters for the breed is 19,438 pounds, the cow giving 13,000 pounds of milk produces only $\frac{13000}{19438}$ or 67 per cent of the average. On the other hand a cow giving 25,000 pounds of milk produces 25,000 ÷ 19, 438 or 129 per cent of the breed's average. The percentages of milk production are tabulated for three groups: those cows giving 13,000 pounds of milk, 19,000 pounds of milk and 25,000 pounds of milk. The first full sister's percentage of milk yield is 67 per cent as shown in column 1. The average percentage of milk yielded by the second full sister is 82 per cent, for this group. This is shown as the dotted bar.

Besides the average production of full sisters we wish to know something more about them. Namely, how much variation will there be in the milk yields of second full sisters when we know the milk production of the first full sister? The information which it is desired to obtain may be illustrated as follows: suppose we have 100 cows which have full sisters whose milk yield is 19,000 pounds or 98 per cent of the average. We know from the above that the average milk yield of these 100 cows will be about 98 per cent of the average for the breed. The question on which we desire information is how much on either side of this average will these 100 cows vary in their milk production. For our purposes we have chosen to state the problem in this way: what limits of milk yield would include 50 out of the 100 cows whose production is nearest that of the average of 98 per cent? These limits would of course be on either side of the average production. It is possible to determine them by arranging the cows in order of their milk production and counting off the first 25 on either side of the average production. The milk production of the 25th cow on either side marks off the limits which would include 50 out of the 100 cows: in other words, the range between which 50 per cent of the full sisters would be found in their milk yield. This method gives a measure of the variation which we may expect in the milk yield of any individual cow on predicting it from the milk yield of a full sister. Thus, where a first full sister's milk yield is 67 per cent, the average of the second full sister's milk yield is 82 per cent and the range of variation necessary to include 50 out of 100 such second full sisters would be 70 per cent to 94 per cent.

This is marked by the ends of the white area in the first column of figure 1. This figure shows that as the production of the first sister increases, the average production of the second sisters also increases. For the second column, where the first full sister gives 98 per cent, the average of the second full sisters is 99 per cent and the range necessary to include 50 out of every 100 second sisters is from 87 to 111 per cent. For those full sisters which have an average milk yield of 129 per cent the second full sisters have an average milk yield of 116 per cent. The range necessary to include 50 out of

every 100 of the second full sisters is from 104 to 128 per cent.

The construction of the columns showing the milk yields of the half sisters from common sire and from common dam is the same as that of the full sisters. The average percentage of milk yield is given as the dotted bar across the white space and the ends of the white space represent the limits necessary to include 50 out of every 100 of the second half sisters.

It is noticeable that full sisters tend to resemble each other in milk yield more closely than do half sisters, due of course to the greater common inheritance which they obtain from both sire and dam instead of from just one parent. Thus for those cows which have a common sire we note that where the first half sisters are 64 per cent in their milk yield the average of the second half sisters is 87 per cent, whereas for full sisters where the first sisters have 67 per cent, the second full sisters have an average of 82 per cent or the full sisters tend to resemble each other in their milk yield nearly 7 per cent more closely than do the half sisters. This same fact is brought out by the other extreme. Where the half sisters have a milk yield of 124 per cent, the second half sisters have an average milk yield of 109 per cent. Where the full sisters have a milk yield of 129 per cent, the second half sisters have an average milk yield of 116 per cent. The full sisters are consequently 3 per cent closer in their milk yield than the half sisters. The same general fact holds for the relation of the milk yield of half sisters with a common dam as compared with the milk yields of full sisters.

A point of considerable importance in pedigree study may now be made. If a sire has a first daughter which is rather poor in milk yield it is more than an even chance that by breeding this sire to this same cow another daughter will be obtained which also will have a relatively poor milk yield. If on the other hand a sire obtains a daughter above average in milk yield it is unwise to change this sire in the hope of getting another daughter from this same cow of greater milk yield than the first, since the chances are more than even of choosing a sire which will decrease rather than increase the milk yield of the resulting offspring.

While the comparison shown in figure does not bring out the facts very clearly, may be stated that the data on which the cor parison is based when analyzed particular for this point show that the relation betwee the milk yields of half sisters is only slight more than half of that between full siste In other words, in attempting to estimate th probable production of an unknown anim by pedigree study if records on relatives a given we can place more confidence in a r cord of a full sister than we can in a reco of a half sister to the animal in which we a interested.

It will be noted that the graphs show close correspondence between the avera milk yields of second half sisters irrespecti of whether they have a common dam or common sire. Such evidence points to th equal effect of the sire and dam on the mil yield of the daughter. This conclusion ha been confirmed by an extended and rath complicated study of the interrelation milk yields of different groups of animals.

The same essential facts are shown for th relation of the butter-fat percentages of fu sisters and of half sisters. This does n mean that milk yield and butter-fat percen age are inherited together, in fact all th evidence points to the conclusion that the are independent or nearly so in the Holstei Friesian breed. This means only that whi the inheritance for the two is brought abo by separate parts in the machine, the qua titative inheritance is approximately the sam both in the milk yield and the butter-fat pe centage. Figure 2 shows the graphs for th butter-fat percentages of these groups of si ters.

In view of these facts we can draw certa conclusions with regard to the value in ped gree study of the records for milk yiel or butter-fat percentages on full sisters or half sisters. The record of a cow predic the probable milk yield of her full sist much more accurately than it does that her half sister whether the half sister be the same sire or from the same dam. Th in purchasing a bull (which has daughters

* Those who are interested in following th subject further will be interested in consulti the writer's book "Milk Secretion," (Willian and Wilkins, Baltimore), as this book contai a much more complete treatment of this enti subject.

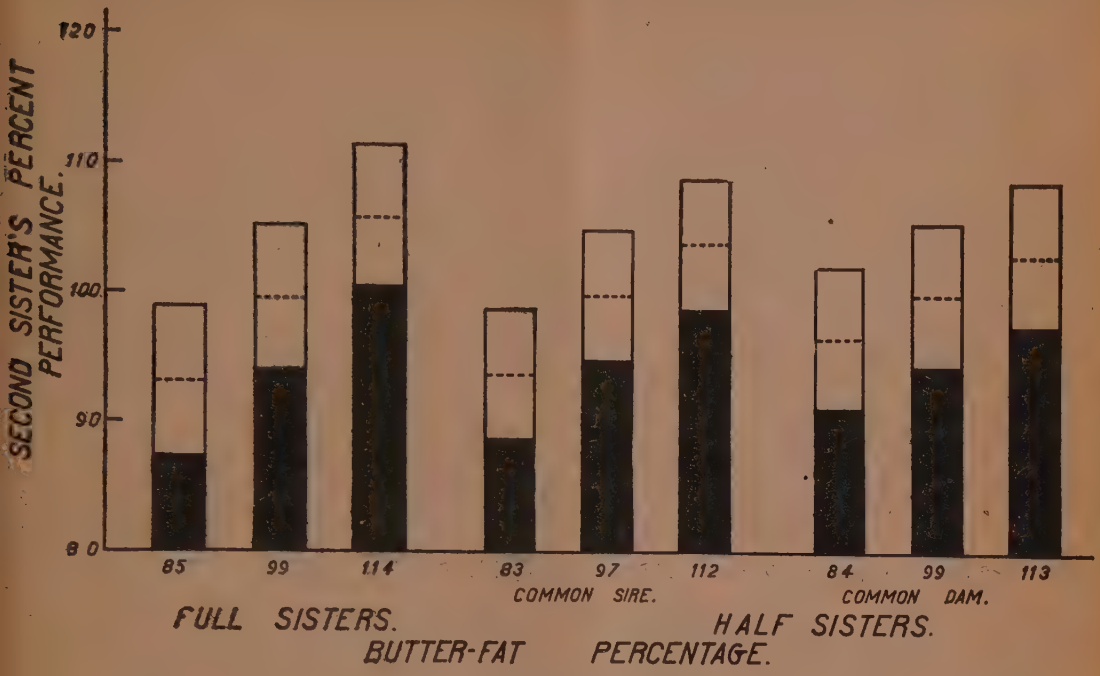


Figure 2. Graphs showing the relation between the butter-fat percentages of full sisters, of half sisters with a common sire, and of half sisters with a common dam. The method of forming this graph is similar to that for the milk yields given in Figure 1. The dotted line represents the average butter-fat percentage of the second full sisters or half sisters, as the case may be, whose first sisters have a given butter-fat percentage. Thus in the case of those full sisters that have a butter-fat percentage of 85 per cent, the second full sisters have an average butter-fat percentage shown by the dotted line of 93 per cent. The limits of the white area on either side of the dotted line mark off the percentages necessary to include 50 out of every 100 such second full sisters. In other words, it gives a measure of the accuracy of prediction for any given individual's record based on the record of its full sister, or half sister, as the case may be. It will be noted from this chart that the butter-fat percentage of second sisters increases as that of the first sisters increases. In other words, there is quite a marked relation between the butter-fat percentages of sisters. This relation is obviously greater for the full sisters than it is for the half sisters. This fact indicates that the greater common inheritance of full sisters, as derived from both sire and dam, has a more marked influence than does the inheritance derived from only one parent.

excellent performance) and bringing him into our own herd we would not expect him to have daughters of the same excellence as he did in the herd from which he came because of the fact that he is going to be used on entirely different cows, perhaps inferior to those to which he had been previously bred. The offspring which he gets will furthermore be only half sisters of those of the herd from which he came, whereas if he were continued to be used in the original herd it is probable that he would get many full sisters and thus maintain more nearly the high level of performance previously established. The same conclusion is to be drawn for the cows which are purchased on the basis of the production of their daughters, for unless they are bred to higher class bulls than those to which they were originally bred it is more than an even chance that their daughters will not do so well as if the previous sire had been used.

Milk Yields of Mother and Daughter.

The study of the milk yields of mother and daughter furnish what is frequently the most direct comparison available to the breeder. The daughters' milk yields are slightly in excess of those of their dams. The average milk yield of the daughters is 19,600 while that of their dams is 18,800 pounds for the maximum production at 8 years and 3 months. There are 216 daughters which come from dams whose milk

yield is over 20,000 pounds. These daughters' average production is 21,778 pounds for the 365-day period. The 395 daughters that come from dams with milk yields less than 20,000 pounds have an average production of 18,393 pounds. In other words, the daughters from cows with productions greater than 20,000 pounds have an average milk yield 3,385 pounds greater than the daughters which came from dams whose milk yields are less than 20,000 pounds.

When the yield of the dam is low, the milk yields of the daughters tend to be higher. They approach the average of the breed. On the other hand when the milk yield of the dam is large, the milk yield of the daughter is also large, although not quite so large. The figures show on a percentage basis the relation of the milk yield of the daughter and dam.

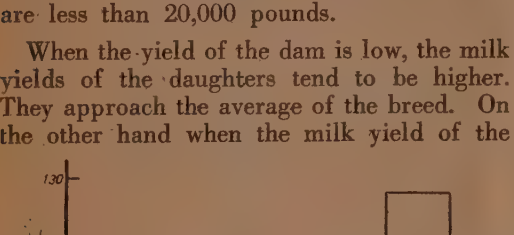


Figure 3. Graph showing the relation between the milk yields of dams and daughters in the Holstein-Friesian Advanced Registry. The productions are given as percentages of the average production for the breed. The construction of the figure is as follows: The dotted line indicates the average milk yield of the daughters coming from dams of a given milk yield. The ends with the white area represent the variation in milk yield necessary to include 50 out of every 100 daughters when they come from dams of a given milk yield. That is, daughters from dams producing 69 per cent have an average production of 85 per cent and 50 out of every 100 of those daughters would have milk yields between 72 per cent and 97 per cent of the breed's average. From these graphs it will be noted that the increase of the dam's milk yield results in an average increase of the daughter's milk yield of somewhat less an amount. Thus for dams wih an average milk yield of 69 per cent the daughters' average milk yield is 85 per cent whereas for dams with milk yield of 133 per cent the daughters' average milk yield is 116 per cent. Or for an increase in the percentage of milk yield of dams of 64 per cent there is an average increase in daughters' milk yield of 31 per cent.

This figure shows that when the dam's milk yield is 69 per cent of the average of the breed the daughters' milk yield is 85 per cent. If the dam's milk yield is 101 per cent, the average daughters' milk yield is found to be 100 per cent. If the dams' milk yield is 133 per cent, the daughters' milk yield is found to be 116 per cent. For an increase in percentage of milk yield of 64 per cent for the dam there has been a resulting increase of milk yield in the daughters of 31 per cent. This increase shows the importance in pedigrees of having dams with records which are relatively high. The record of the dam is one of the best pieces of evidence on which to base any estimate of the probable production of the daughter. In fact this close relationship between the milk yield of daughter and dam makes it an open question if for the small breeder it is not better to purchase daughters from relatively high producing dams than it is to pay too much attention to and too much money for a supposedly high producing bull. The reason for this lies in the fact that a daughter's production may be predicted much more accurately from the record of her dam than can the record of a sire's offspring from the records of any of the sire's ancestors. This point we shall bring out further in the comparison of the records of grandparents with those of their granddaughters.

Another question on which we desire information is how much on either side of this average will these 100 cows vary in their milk production. For our purposes we have chosen to state the problem in this way. What limits of milk yield would include 50 out of 100 cows whose production is nearest the average of 100 per cent? These limits would of course be on either side of the average production. It is possible to determine them by arranging the 100 cows in the order of their milk production and counting off the first 25 on either side of the average production. The milk production of the twenty-fifth cow on either side would be the limits which would include 50 out of every 100 of such daughters. In other

words, the twenty-fifth cow would mark the range between which 50 per cent of the daughters would be found in their milk yield. This method gives a measure of the variation which we may expect in the milk yield of any individual cow on predicting it from the milk yield of her dam. Thus where the dam's milk yield is 69 per cent the average milk yield of the daughters is 85 per cent and the range of variation necessary to include 50 out of every 100 such daughters would be from 72 per cent to 97 per cent. These limits are marked off by the ends of the white area of the first column of figure 3. In a similar manner the other columns represent the average production and range in production of daughters coming from dams of other grades of production.

Figure 3 shows that as the production of the dam increases the average production of the daughters increases also. Where it possible to picture it, the relation of sire and daughter would appear the same as figure 3 for the relation between dam and daughter, as it can be shown that the correlation between the milk yields of sire and daughter are essentially of the same value as the correlation between dam and daughter where we have actual milk yields on which to determine the correlations. From these data and the data on the average milk production of daughters with given grades of dams we are in a position to furnish a fairly accurate means of predicting milk yield when given pedigree records showing the milk production of the dam. The same is also true for the butter-fat percentage for although milk yield and butter-fat percentage are inherited independently, the butter-fat percentage follows the same laws as that of milk yield. These data are given in figure 4.

Figure 4 shows that as the butter-fat percentage of the dam increases the average butter-fat percentages of the daughters from these dams also increases. The variation of the daughters, while fairly large in amount, is still small enough so that the prediction of the daughter's butter-fat percentage from that of her dam is one of the preeminently important single considerations in pedigree study.

The next important point is the relation between the milk yields of grandparents and the milk yields of their granddaughters.

Relation of the Milk Yields and Butter-fat Percentages of Grandparents and Granddaughters.

From the point of view of general breeding and pedigree study the record on the paternal granddam is probably of most importance. It is on this record that bulls are frequently purchased, in fact it is the most important record in the pedigree when these bulls are so young that they have no daughters of their own. For this reason the records of this parent will be taken as illustrative of the effect of the grandparents on the milk yield and butter-fat percentages of their granddaughters.

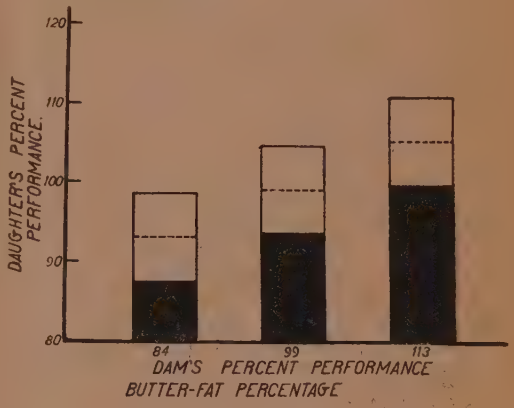


Figure 4. Graphs showing the relation between the butter-fat percentage of daughters and dam as obtained from Holstein-Friesian Advanced Registry data. The construction of this figure is similar to that of figures 1 and 2, the dotted line indicating the average butter-fat percentage of the daughters and the ends of the white areas the variation necessary to include 50 out of every 100 daughters when they come from dams of a given butter-fat percentage. From this graph it will be noted that the increase in the dam's butter-fat percentages results in an average increase of the daughter's butter-fat percentage of somewhat lesser amounts. Thus for dams with a butter-fat percentage of 84 per cent of that of the breed's average, the daughter's average butter-fat percentage is 93 per cent of the breed's average. On the other hand, for dams which have an average butter-fat percentage of 113 per cent the daughters have an average butter-fat percentage of 105 per cent, or for an increase of 29 per cent in the dam's butter-fat percentage there is a corresponding increase of 12 per cent in the daughter's butter-fat percentage. These facts show the importance of having dams with a relatively high butter-fat percentage in the pedigree when one of the objects of breeding is to raise the butter-fat percentage of the herd.

Before taking up this point we may summarize briefly the results of a study of the relations of milk yields of the grandparents to the milk yields of their granddaughters. The study of the data reveals no significant differences between the influence of the grandparents taken individually, whether it be on the sire's side or the dam's side of the pedigree, on the production of their offspring either in milk yield or butter-fat percentage. The grandparents have only half the relation to the milk yields and butter-fat percentages of their granddaughters that the parents have. In other words, the record on a grandparent is nowhere near so good a measure, by which to predict the probable milk yield or butter-fat percentage of their progeny a generation removed, as the record on the dam of that progeny. From the records of the Holstein-Friesian breed we find the following comparison between the milk yields of granddaughters and paternal granddams. If the milk yield of the paternal granddam is low, say 10,000 pounds, the milk yield of the daughter will also be low, 17,297 pounds, when considered in comparison with the rest of the daughters. If the milk yield of the granddam is large, 30,000 pounds, the milk yield of the granddaughters has a large average, 22,373 pounds, when compared with the rest of the granddaughters. This increase is not anywhere near so pronounced as that for the relation of daughters' and dams' milk yields. In other words, the point brought out by this comparison is that the grandparents have an effect on the milk yields of their progeny, even though they are a generation removed but that this effect is not so great as the effect of the immediate parent. Thus in all pedigree studies we can not place so much weight on a record occurring in the second generation as we can on a record occurring in the first generation.

Furthermore the variation of the granddaughters with paternal granddams of a given production is much greater than the variation found for daughters of a given grade of dams. Thus for paternal granddams of 14,000 pounds, a variation in the milk yield of 15,426—21,198 pounds is necessary to include 50 out of every 100 granddaughters. A prediction of the milk production of a granddaughter from the grandparent's record cannot be made so accurately as that of a daughter from the dam's milk yield. This conclusion is also true for the butter-fat percentage.

It is unnecessary to take the reader over the evidence for the third generation for this evidence is quite scattering due to lack of numbers. General conclusions from such an analysis can be stated very simply. The third generation individuals are found to influence the milk yields and butter-fat percentages of their progeny two generations removed to but a very slight extent, much less than do the grandparents. We have then carried the examination of the records of the pedigree in their effect on the performance of the animal pedigreed to a limit so far as any practical conclusions can be drawn for such records.

There is one other phase of the pedigree which we should probably examine because of the frequency of its occurrence in pedigree study. In an examination of the methods of recording the performance of the sire it is frequently noted that this sire has a brother which in turn has daughters of very excellent performance. The conclusion is left to the breeder looking at this pedigree that these brothers' daughters will probably indicate what the unknown sire's daughters will do in their milk yield and butter-fat percentage. A little consideration shows that such a sire's daughters are first cousins to those of this brother. We have, therefore, to compare the milk yields and butter-fat percentages of first cousins to determine how good an indication such records really are and how good a basis they actually may be for forming judgment as to the probable productive worth of an animal. We find, stating the conclusions broadly, that these cousins are only about half as good indicators of the probable milk yield and butter-fat percentage of the animal pedigreed as are records on any of the grandparents. The records of cousins are much less effective, therefore, than records of the parents.

This brief review of the main conclusions from the study of inheritance of milk yield and butter-fat percentage in relation to the reading of a pedigree brings out one further point, namely, the best combinations of ancestors or of relatives to predict the probable productive worth of an animal. Here again without going into the evidence the combination which has been found to be of the most

value are records on a full sister and on the dam for predicting the probable milk yield or butter-fat percentage of a given animal. The next most important records are the records of a half sister by the same sire and a record on the dam for predicting the milk yield or butter-fat percentage of an unknown animal. Thus it is records immediately next to the animal pedigreed which are most important in pedigree study. We can in a sense discard as useless, unless they are very numerous, the records of the third and fourth generation individuals. They can, I think, be discarded even though they are very numerous because with these famous animals in any number in the third and fourth generation there is something wrong with any pedigree that does not show records in the first and second generation on the animals which come from these famous ancestors. A man cannot afford to leave the progeny of such animals unrecorded as to performance and therefore we have a right to expect performance records in such a pedigree.

What are the Essentials in Pedigree Writing and Reading ?

The results of this brief summary of the long, tedious, painstaking work on inheritance in relation to pedigree writing and reading may be concluded as follows. First there appears to be little or no influence of inbreeding, of relationship, or of famous ancestors on the production of the progeny of dairy sires. It will be noted that the evidence shows that the inbreeding and relationship which occurs in the ordinary pedigrees as found in our purebred breeds is relatively small in amount. The evidence from extensive experiments (on small animals particularly) shows that very intensive inbreeding such as mating brother and sister for a number of generations will generally result in the concentration of the prepotency of this animal but also in a decline in vigor in such inbred animals and a probable reduction in fertility. These last results may, however, be avoided by very careful selections.

It is indicated further that it is desirable to have animals which are registered because these registration papers show that a definite effort has been made to breed these animals to certain types of production and because this definite effort tends to make these animals pure for these types of production and consequently transmit them as increased milk yields and butter-fat percentages to their offspring more frequently than animals of unknown breeding with probable mixed ancestry.

It is further shown that the parents and grandparents, sisters and half sisters, and to some extent cousins are the important relatives on which to base an estimate of the productive worth of an animal. As a pedigree goes beyond three or four generations the ancestors in it get so far removed from the animal pedigreed that the effect of any worthy ancestor even though pure for high production is diluted so much by the other ancestors in coming down through the generations that its effect on the animal pedigreed is so slight as to be of little or no value as a prediction of the progeny's probable production.

It is further shown that the animals on which greatest dependence may be placed in reading a pedigree are the recorded performances of the dam, full sisters, and half sisters. Next to these come the recorded performances of the grandparents.

These results of a strict and critical study of inheritance in dairy cattle are apparently confirmed by the opinion held by dairy cattle breeders in Denmark. Anthony (16) in showing the way in which sales catalogs are put up by Danish Breeders indicates that they give the records on three generations of the pedigree for the female ancestors. These are given as the age of the cow, her milk yield and butter-fat percentage and the number of pounds of butter produced. The pedigree is further completed by giving the prize winnings of the male ancestors for two generations. Judges then give the animal in question a rating as to its type, a rating as to the production of the ancestors and as to the external appearance of the ancestry.

To this record the writer would add the records of the progeny as the author's studies have shown these records important in indicating the progeny performance of any pedigreed animal. A pedigree of this type

is the unvarnished record worthy of a careful consideration of any breeder either reading or writing pedigrees.

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The Sclerotinia Disease of Sunflowers and Other Plants.

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The fungus causing stem rot of sunflowers, and diseases of several other plants, has been kept under observation in Manitoba since 1920. An account of the disease was given in this journal in 1921 (2). This disease on sunflowers has attracted attention also in British Columbia (5) Ontario (7), Quebec (1), New Brunswick (3), and it is also reported from Alberta and Prince Edward Island (14). It has also been found in several of the States, and is especially troublesome in Montana (15). Baribeau (1) has given a good account of the disease in Quebec. This Sclerotinia is characterized by the production on all crops attacked of black, hard, oval or irregular bodies, called sclerotia, and it can usually be recognized by these.

In view of the fact that uncertainty existed as to the extact species of Sclerotinia which was causing the trouble, attempts were made to germinate the sclerotia and produce apothecia and ascospores. While Cunningham (3) records as *S. Libertiana* Fcl. the fungus which attacked various vegetables as well as sunflowers, he does not mention having obtained apothecia, although he doubtless had obtained them from sclerotia from at least some of the vegetables with which he worked. Baribeau (1) did not succeed in obtaining apothecia. In most cases the fungus is reported as "Sclerotinia sp." or "probably *S. libertiana*". Mrs. Jones (8), however, obtained asci and spores from sclerotia produced on sunflowers in Wisconsin, and concluded that the fungus was *S. libertiana.* Miss Wakefield (16) points out that *S. sclerotiorum* (Lib.) Massee is a prior name which should be used for this fungus.

Sclerotia from sunflowers placed in damp chambers either before or after exposures to periods of freezing or placed in sand and buried outside over winter either did not germinate, or produced only mycelium. However, sclerotia from the exterior of the underground stems of sunflowers left in the field over winter were found to be showing stipes in May of 1924, and these were brought in and placed in damp sand in Petri dishes. The stipes continued to grow, turning sharply toward the light; after a time they were moved near a window, and the covers of the dishes partly opened, whereupon good apothecia were obtained (Platel, Fig.1). Spores were shot out in clouds when the covers were opened. The spores in the fresh condition were found to be 10 - 12½ (occasionally to 14) by 5 - 6½μ, and the asci 100 to 150 by 8 to 10μ. The smaller measurements recorded by Mrs. Jones (8) are, as she suggests, doubtless to be explained by the fact that her material had been stored in alcohol. These measurements agree with those recorded by Saccardo for *S. libertiana,* (i.e., *S. sclerotiorum*).

This stem rot continues to be an important disease of sunflowers in Manitoba. It is especially common upon sunflowers planted in gardens, or in areas which at some previous time had grown vegetables, since the same fungus is very prevalent on many vegetables (3, 2). On the Agricultural College plots, where sunflowers have followed cereals, the disease has been almost entirely absent. Once this fungus becomes established in the soil, however, it remains there for some time, and crop rotation should be practised. We found that after one year without sunflowers (during which cereals had been grown on the soil), the fungus was still present and produced stem rot upon sunflowers planted the second year. The farmer in Western Canada can greatly lessen the danger of loss from this disease by planting his sunflowers upon fields which have grown grain crops, for the fungus does not attack grains or grasses.

During the summer of 1922, which was rather moist and warm at Winnipeg, sclerotia developed upon alfalfa, soy beans and red clover. I was not in Winnipeg that summer,

PLATE I.

Figure 1. Two stages of the germination of sclerotia of *S. sclerotiorum* from sunflowers. Enlarged.

Figure 2. The small sclerotia are those obtained from alfalfa seed; the larger ones to the right were in soy-been seed.

Figure 3. Above, sclerotia and seeds of red clover; below, the large irregular sclerotia obtained upon potato plug cultures of the sclerotia shown above. The cultures from sunflower, alfalfa, soy-bean, etc., all produced sclerotia similar to the ones shown below.

Figure 4. Sketch to show one method of fusion between hyphae from two different cultures. The arrows indicate the direction of growth of the hyphae. They appear often to be mutually attracted at points where the hyphae approach each other.

and did not see the affected plants. There was not, however, a conspicuous injury noted upon them, yet when they were threshed sclerotia became separated out from the plants and were found with the seeds. The sclerotia from alfalfa and red clover were small and oval or roundish; those from soy-bean were larger (Plate 1, Figs 2, 3). These sizes were of course partially accounted for by the fact that only sclerotia similar in size to the respective seeds would get through the separator with the grain. It is obvious that these sclerotia might easily be disseminated with such seeds. A search upon the old alfalfa plants in the field in the late autumn of 1922 revealed an occasional sclerotium in the stems. The elongated shape of the sclerotia from alfalfa and soy-bean evidently resulted from their growth within the stems of these hosts. In culture the sclerotia from each host produced mycelium, and sclerotia of irregular size, identical in appearance to those in cultures of the fungus isloated from sunflowers. Reinking (12) reports a Sclerotinia to be serious on Soy-beans in the Philippines.

The Sclerotinia of clover and alfalfa is usually referred to as *S. trifoliorum* Erik. (6, 17). Eastham (4) has reported this disease from British Columbia. Stewart, French and Wilson (13), however, reported *S. libertiana* to cause a wilt of alfalfa. Many consider that these two names refer to the same species of fungus. Wolf and Cromwell (17) consider that there is a morphologic difference between the two, although they did not find any marked difference in pathogenicity: both species, as they considered them, infected both lettuce and crimson clover.

I succeeded early in 1923 in obtaining apothecia from the sclerotia from alfalfa. These bore asci 120-140 by 7½ - 10μ, and spores 10 - 15 by 5½ - 6½μ. These measurements also agree well with those of *S. sclerotiorum*. Wolf and Cromwell record that *S. trifoliorum* has larger asci and spores, but smaller hyphae and sclerotia, than has *S. sclerotiorum*. I found no difference in size or appearance of mycelium or sclerotia in cultures from the various sources. Small microconidia, or "gonidia", are commonly produced by all the cultures I have examined.

Since the affected legumes were grown adjacent to the sunflower field which had been affected by the Sclerotinia, and since the cultures were similiar, I suspected that one and the same fungus was present. I endeavored to prove this in two ways: first by tests of the fusions of hyphae in cultures, and second by cross inoculation tests.

Fusion between hyphae is a common vegetative phenomenon in the fungi. Matsumoto (10) used this as one criterion of the similarity of "strains" of Rhizoctonia. It is evident that if the hyphae from the fungus from alfalfa would fuse with the hyphae from the fungus from sunflower, the fungi must be similar if not really identical. Hanging drops in Van Tieghem cells were inoculated at about 2mm. apart with bits of mycelium from two different sources, and as the hyphae grew into contact, they were watched under the microscope for fusions. As a result of these tests, I found that:—
The hyphae from—

Alfalfa	fused	with	those	from sunflower
Red Clover	"	"	"	" soy-bean
Soy-bean	"	"	"	" sow thistle
Sunflower	"	"	"	" soy-bean
Parsnip	"	"	"	" alfalfa

This indicated that the isolations from alfalfa, sunflower, red clover, soy-bean, sow thistle, and parsnip were all the same fungus. Since the one from alfalfa appeared to be *S. sclerotiorum*, evidently they all were. Subsequently the sunflower form also proved to produce apothecia characteristic of *S. sclerotiorum*.

Cross inoculations were first made in the laboratory. The cultures isolated from sunflower and from alfalfa both rotted parsnips, those from soy-bean, red clover, alfalfa and sunflower each rotted carrots. In the field a slight rot of soy-beans was obtained from the fungus from sunflower, and typical rot of sunflower from the culture from soy-bean. Inoculations were ineffective in many cases, perhaps because of the dry weather prevailing in 1923. It may be noted here that no injury was found in 1923 in the same clover and alfalfa fields which had been affected in 1922.

It appears evident that *Sclerotinia sclerotiorum* is the fungus that has attacked the various plants in Manitoba. It also causes a considerable loss of carrots and parsnips in storage. It is recorded from a large number of other vegetables, including beans, beets, celery, cabbage, parsley, tomatoes, potatoes (3, 9), lettuce, and several ornamental palnts. *S. trifoliorum* may be a distinct species upon alfalfa and clover (6, 17), but *S. sclerotiorum* also may attack these plants, and it may be possible that *S. trifoliorum* may yet prove to be only a synonym of *S. sclerotiorum*.

While many crops may be attacked by this fungus, it has so far been found causing special injury in Manitoba only upon sunflowers in the field, and upon carrots and parsnips in storage. Climatic conditions here are usually too dry, and often too cool, for the maximum development of this fungus, and I do not believe it will prove to be a serious disease of alfalfa, clover, soy-beans, or of most other plants, except in occasional instances. It has never been found upon potatoes here, although it is recorded from New Brunswick (9). In cases in which the rot of carrots, parsnips or other vegetables in storage has occurred, a thorough cleaning and disinfection of the cellar or bin would prevent the over-summering of the fungus in such storage houses. The occurrence of trouble in a crop from this fungus should be met with a rotation of non-susceptible crops, such as cereals, corn, or such vegetables as are not mentioned herein as susceptible. It was found in Pennsylvania (11) that the fungus virtually disappears from the soil after two years during which non-susceptible crops are grown.

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Losses in Wilting and Ensiling Sunflowers.*

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The sunflower as a farm crop has apparently come to stay. The first perfervid enthusiasm with regard to this supposedly wonderful new forage has passed, but a calmer consideration of its merits has shown it to have a definite place at least in some districts. Our experiments have proved it to have a decidedly longer growing season than corn (owing to the greater frost-resistance of sunflowers) and, when sufficient moisture is available, a greater yielding capacity. On the other hand it does not resist drought as well as corn, and sunflower silage is scarcely equal to corn silage in quality and feeding value.

One of the problems common to many kinds of silage in greater or less degree, but particularly acute in the case of sunflowers, is that of drainage losses from the silo. Sunflower silage packs very closely, much more so than corn, and so has a higher specific gravity. This, coupled with the fact that it is very high in moisture content, often results in a very voluminous flow of juice from the bottom of a newly filled silo. To avoid this loss the wilting of the sunflowers for a few days before filling the silo has been practised by some of our farmers, and has been recommended in a publication from the Montana Experiment Station (2). In this publication, Blish states that the quality of the resulting silage was improved by wilting, and points out that the practice reduced the labour of handling, as a lot of surplus water was gotten rid of in this way. Furthermore, he states that "The losses... (both by drainage and otherwise) are reduced to a minimum." In another place he dismisses the probable "slight loss" during wilting as "hardly to be considered of any serious consequence."

This seems a sufficiently logical assumption, but our experimental results do not bear it out. We found, in fact, that the problem of eliminating these losses is not nearly so simple as might be supposed.

Drainage Losses

To estimate drainage losses accurately would require the use of water-tight silos, but with provision for drainage into receptacles where the juice could be measured and sampled. With the ordinary stave silo, such as we have at the University of Alberta, the pressure developed forces the juice in thin streams between the staves, at numerous points in the lower half of the walls. In these circumstances the best that could be done was to sample the juice for analysis, and make a rough estimate, based on other measurements, of the probable quantity lost.

TABLE I.—COMPOSITION OF JUICE FLOWING FROM SILO FILLED WITH FRESHLY CUT SUNFLOWERS.

(Sample collected Sept. 8, 1923)

	Percent.
Coagulable protein (albuminoid)	0.07
Non-coagulable protein	0.63
Total protein	0.70
Reducing sugars	3.71
Invert sugar	0.41
Total sugars	4.12
Solids undetermined (soluble starch, ash, etc.)	4.48
Total solids	9.30
Specific gravity of juice 1.042	

Table I contains an analysis of a sample of drainage juice collected from one of the University farm silos, which had just been filled with freshly cut sunflowers.

Godden (4) found the composition of the drainage liquid collected at five successive periods during the first 24 days after filling to be practically constant, so that we feel justified in using the figures in Table I as representative of the composition of the whole volume of juice lost. The actual magnitude of the volume of drainage can be only approximately estimated. Blish (2) measured it accurately for experimental silos containing about 1000 pounds of sunflowers, weight-

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ed at the top with several hundred pounds of rock, and found it amounted to about 10 percent of the weight of fresh sunflowers with which they were filled. But in a large silo, with enormously greater pressure, the loss would undoubtedly be much higher.

The difference between the weight of sunflowers put into the silo and the weight of silage taken out represents the total losses. After losses due to fermentation have been deducted, the remainder must represent approximately the drainage losses. Blish (2) found the loss in weight unaccounted for by drainage varied from 12.2 percent in the case of sunflowers cut in the bud stage, to 3.5 percent in the case of those cut when seeds were fully formed except in the centre of the head. Amos and Woodman (1) buried a sample of sunflowers, cut in full flower, in a large, loosely woven bag in the centre of a small experimental wooden silo, and found on opening the silo three months later that this sample had lost 6.9 percent of its original wet weight, and 4.8 percent of its dry weight. Peterson, Fred, and Verhulst (7) cite the results of eight years work at three experiment stations, which show an average loss of dry matter in corn silage amounting to 18.4 percent. However, it will be shown later that the percent loss of dry matter in the silo may be greater than that of moisture, so that it is perhaps not safe to estimate the maximum loss by fermentation at more than 15 percent of the green weight. The total losses, however, may be much greater. Dowell and Flack (3), in an earlier test at the University of Alberta, found only 60 percent of the weight of sunflowers put in the silo to be available for feeding. They reported that juice ran out of the silo for three weeks after filling, though the sunflowers used had been wilted from one to three days. It appears, therefore, that drainage losses may reach 20 to 25 percent of the weight of fresh sunflowers.

A loss of 20 percent of the green weight of sunflowers containing 15 percent dry matter, by drainage of juice containing 9.3 percent solids (Table I), would be equivalent to a loss of 1.86 pounds dry matter per 100 pounds fresh sunflowers, or 12.4 percent of the total dry matter. The mois-

TABLE II.—LOSSES DURING WILTING OF SUNFLOWERS.

	Total	Moisture	Dry Matter	Crude Protein	Ether Extract	N-free Extract	Ash	Crude Fibre
A.—Weight of each constituent actually ensiled per 100 lbs. freshly cut sunflowers.								
1921.								
Freshly cut	100.	86.56	13.44	2.12	0.36	5.40	1.65	3.91
Wilted 8 days ...	66.75	56.09	10.65	1.12	0.25	4.80	1.28	3.20
1922.								
Freshly cut	100.	83.54	16.46	2.97	0.45	8.14	2.41	2.49
Wilted 3 days ...	92.76	78.66	14.09	2.02	0.43	7.42	1.64	2.58
" 6 " ...	84.72	71.61	13.11	1.76	0.42	6.60	1.52	2.81
" 9 " ...	72.30	59.64	12.65	1.52	0.36	6.27	1.49	3.01
B.—Weight of each constituent lost during wilting. *								
1921.								
Freshly cut	—	—	—	—	—	—	—	—
Wilted 8 days ...	33.25	30.47	2.79	1.00	0.11	0.60	0.37	0.71
1922.								
Freshly cut	—	—	—	—	—	—	—	—
Wilted 3 days ...	7.24	4.88	2.37	0.95	0.02	0.72	0.77	+0.09
" 6 " ...	15.28	11.93	3.35	1.21	0.03	1.54	0.89	+0.32
" 9 " ...	27.70	23.90	3.81	1.45	0.09	1.87	0.92	+0.52
C.—Percent of each constituent lost during wilting *								
1921.								
Freshly cut	—	—	—	—	—	—	—	—
Wilted 8 days ...	33.2	35.2	20.8	47.2	30.5	11.1	22.4	18.2
1922.								
Freshly cut	—	—	—	—	—	—	—	—
Wilted 3 days ...	7.2	5.8	14.4	32.0	4.4	8.8	31.9	+ 3.6
" 6 " ...	15.3	14.3	20.3	40.7	6.7	18.9	36.9	+12.8
" 9 " ...	27.7	28.6	23.1	48.8	20.0	23.0	38.2	+20.9

* The *plus* signs denote gains.

ture content of the silage by such a drainage loss would be reduced from 85 to 83.6 percent. A drainage loss of 25 percent of the green weight under the same conditions would mean the loss of 15.5 percent of the dry matter, and a reduction of the moisture content to 83.1 percent. In spite of the fact that the probable drainage losses seem astonishingly high, the residual moisture content would still be so great as to make them easily possible. The seriousness of the losses is aggravated by the fact that they consist largely of soluble, easily digestible constituents.

Variable Composition of Sunflowers

There are other and more cheerful deductions which may be drawn from the data of Table I. A sugar concentration of 4.12 percent in the juice is equivalent to 3.86 percent in the fresh sunflowers. Blish (2) reports 1.6 percent total sugar in sunflowers grown at Bozeman, Montana, and 0.3 percent in those grown under irrigation at Huntley, Montana. At the latter station the sunflower silage produced was of poor quality, showing evidence of putrefactive fermentation such as is characteristic of silage containing insufficient fermentable carbohydrates. The abundance of sugar present in Edmonton-grown sunflowers should ensure a desirable type of fermentation and high quality silage.

The protein content of 0.70 percent in the juice of Edmonton sunflowers is to be compared with 0.25 percent in the juice of Bozeman sunflowers (as reported by Blish), and the total solids of 9.3 percent in the former with 5.1 percent in the latter.

It must be concluded that sunflowers vary greatly in composition under the influence of environmental conditions, and that from this point of view the Edmonton district is very favourable to the crop.

Losses During Wilting

In Table II are shown the losses which occurred during the wilting of sunflowers, in two experiments. In 1921 the crop was in full bloom when cut. One experimental silo was filled at once with fresh sunflowers, using a small hand feed-cutter in the field, the cut material being sampled for analysis. A further lot of sunflowers, sufficient to fill another silo, was allowed to wilt in small piles in the field, the piles being weighed before and after wilting. It was the intention to ensile them at the end of 3 days, but unfortunately a rainfall of 0.47 inch intervened, and they were allowed to lie 8 days. To avoid this complicating factor, in 1922 the sunflowers intended for wilting were stored at once on a barn floor, spread out in a layer one bundle thick, and good ventilation provided by open windows on both sides. Three separate lots were stored thus, for ensiling at the end of 3, 6, and 9 days respectively. The crop was only about 10 percent in bloom when cut.

The results recorded in Table II, of analyses of material wilted for various lengths of time, revealed unexpectedly large losses of dry matter during the wilting process. The 1921 crop lost, in 8 days, 2.79 lbs. dry matter per 100 lbs. fresh sunflowers, or 20.8 percent of its total original content of dry matter. The 1922 crop lost, in 3, 6, and 9 days respectively, 14.4, 20.3, and 23.1 percent of dry matter. The distribution of these losses, among the various constituents determined, is shown in the table. The greatest actual loss occurred in the carbohydrate fraction ("N-free extract"), but the crude protein suffered the greatest percentage loss. Apparently catabolic activity (respiration, etc.) in the plant is accelerated during the wilting process. With slow drying of very succulent tissue this is rather to be expected, as diffusion of enzymes might easily result from the weakening of the cell organization. Crude fibre, on the other hand, in the 1922 series, when conditions were better controlled, shows a gain during wilting, thus accounting for part of the loss in "nitrogen-free extract". It is noteworthy that the loss of dry matter during 3 days' wilting is as great as that incurred by a drainage loss of 25 percent of the green weight of sunflowers ensiled in the fresh condition. In both cases it seems probable that the most easily digestible constituents are those which disappear most rapidly.

Quality of Silage

The sunflowers, both fresh and wilted, were ensiled in wooden stave experimental silos, 22 inches diameter by 4 feet in height, holding about 300 to 400 lbs. of sunflower silage, with loose fitting covers weighted with stone. Two of these containers appear in the experimental silo-filling scene shown in Plate I.

PLATE I—Filling experimental silos at the University of Alberta.

Previous experience had shown it possible to make normal silage in these containers, sufficient in quantity for chemical study as well as simple palatability tests. In all cases the silos were opened about nine months after filling.

The character of the fermentation is shown by the data of Table III. The significance of the various determinations and the methods used have been discussed by one of the writers in an earlier paper (6). It should be mentioned that the formol-titration for amino nitrogen, used in the earlier work, was abandoned in favour of the Van Slyke method, and the method of making a water extract by shaking was superceded by pressing out the juice with a hydraulic press. The nitrogen in the juice, after centrifuging, is reported in the table as "water-soluble," though of course the solvent is not pure water. In order to calculate the percent of constituents determined in the juice to terms of silage (as reported in Table III) it was necessary to determine the specific gravity and solid content of the juice.

TABLE III.—CHARACTER OF FERMENTATION AND QUALITY OF SILAGE FROM FRESH AND WILTED SUNFLOWERS.

Kind of Silage.	Quality as judged by appearance and odour.	Moisture.	Total acid.	Non-volatile acid as lactic.	Volatile acid as acetic.	Ratio of non-volatile to volatile acid.
1921.	%	%	%	%	%	
Freshly cut	85	87.55	.840	.502	.338	1:0.67
Wilted 8 days	90	85.75	.832	.542	.290	1:0.53
1922.						
Freshly cut	90	87.72	1.004	.316	.688	1:2.17
Wilted 3 days	100	87.55	.592	.115	.477	1:4.15
" 6 "	95	86.82	.922	.358	.564	1:1.57
" 9 "	90	84.94	1.451	.940	.511	1:0.54

Kind of Silage	Amino nitrogen as crude protein.	Water-soluble nitrogen as crude protein.	Total nitrogen as crude protein.	Ratio of water-soluble nitrogen to total nitrogen.
1921.	%	%	%	
Freshly cut	.588	.939	1.58	1:1.68
Wilted 8 days	.254	.731	1.98	1:2.71
1922.				
Freshly cut	.565	.854	1.69	1:1.97
Wilted 3 days	.592	.939	1.67	1:1.78
" 6 "	.711	1.087	1.55	1:1.42
" 9 "	.726	1.088	1.85	1:1.70

In most cases wilting improved the quality of the resulting silage to some extent, as judged by appearance and odour at the time of sampling, and by the avidity with which it was eaten by stock. Silage from freshly cut sunflowers tended to be rather slimy in appearance. On the other hand, 9 days wilting was apparently excessive, as the quality and palatability of the silage fell off in this case. The irregular results in regard to acidity cannot be explained at present. The increase in amino nitrogen and water-soluble nitrogen with length of wilting, in the 1922 series, is indicative of protein-splitting. The data at hand do not make it possible to say what proportion of this splitting took place during the wilting, and what proportion in the silo. However, the heavy losses of protein during wilting make it plain that considerable hydrolysis occurred then, and the reverse relationship in the concentration of split proteins in 1921 may perhaps be accounted for by the leaching of the soluble split products by the heavy rainfall to which the piles of wilted sunflowers were subjected. Protein splitting is of course undesirable, not only on account of the wastage it may involve, but also because of evil-smelling products which may result, to the consequent detriment of the palatability of the silage.

Changes During Wilting and in the Silo

In Table IV, the proximate analysis of fresh and wilted sunflowers, before and after ensiling, are arranged in a form convenient for comparison. Irregularities which occur in the figures may probably be to a considerable extent ascribed to errors in sampling. In a recent paper, Neidig and Snyder (5) have shown the great variation in the composition of different parts of the plant; the leaves may run two or three times as high as the stems in certain constituents, while the flower heads may be totally different from either. In the work here reported the sampling was done after the plants had been run through a silage cutter, and although ordinary precautions were taken to secure representative portions, the considerable size of the pieces of tissue made small errors almost inevitable. In future, only samples consisting of a number of entire plants will be taken before ensiling, and these will not be resampled until they have been finely ground. Samples of silage cannot of course be taken in this way, but should be several kilograms in size, and consist of a composite of smaller samples taken from several different parts of the silo. But in spite of irregularities, certain unmistakeable general trends are apparent in the figures.

With regard to the analyses of the material before ensiling, the changes during wilting were brought out more clearly in the form in which they were reported in Table II, than they appear on the basis of percentage composition, in Table IV. Since the latter is the customary method of reporting results, it is important to note that it involves a tendency for losses in one constituent to be obscured by corresponding losses in others. This is especially noticeable in the moisture content, which appears to decrease very little during the wilting process, a rather astonishing result, explainable only by the fact brought out in Table II, that the percentage loss of dry matter during wilting was only slightly less than that of moisture, so that the relative quantities of the two remained fairly constant. The moisture was determined in all cases in a vacuum electric oven at 98°C., and of course would include small amounts of other volatile substances as well as water. In some cases in Table IV, changes during wilting which appear on the percentage basis to be gains, represent actual losses in absolute quantity, the anomalous results arising merely from the relatively greater decrease in other constituents. However, some of the more conspicuous features of the wilting process, such as the losses in protein and gain in crude fibre, are still evident on the basis of percentage composition.

TABLE IV.—COMPOSITION OF FRESH AND WILTED SUNFLOWERS BEFORE AND AFTER ENSILING.

	Before Ensiling		After Ensiling	
	Dry Basis. %	Wet Basis. %	Dry Basis. %	Wet Basis. %
(1) Moisture Content.				
1921.				
Freshly cut	—	86.56	—	87.55
Wilted 8 days ..	—	84.03	—	85.75
1922.				
Freshly cut	—	83.54	—	87.25
Wilted 3 days ..	—	84.81	—	87.65
" 6 " ..	—	84.53	—	86.83
" 9 " ..	—	82.50	—	84.89
(2) Protein Content.				
1921.				
Freshly cut	15.79	2.12	12.66	1.58
Wilted 8 days ..	10.58	1.69	13.89	1.98
1922.				
Freshly cut	18.07	2.97	13.26	1.69
Wilted 3 days .	14.40	2.19	13.53	1.67
" 6 " ..	13.47	2.09	11.79	1.55
" 9 " ..	12.05	2.11	12.23	1.85
(3) Ether Extract.				
1921.				
Freshly cut	2.70	.36	2.23	.29
Wilted 8 days ..	2.62	.39	2.16	.31
1922.				
Freshly cut	2.75	.45	2.98	.38
Wilted 3 days ..	3.10	.47	1.90	.23
" 6 " ..	3.22	.49	2.03	.27
" 9 " ..	2.89	.50	2.40	.36
(4) Nitrogen-free Extract.				
1921.				
Freshly cut	40.16	5.40	40.97	5.09
Wilted 8 days ..	44.57	7.15	41.92	5.98
1922.				
Freshly cut	49.37	8.14	44.71	5.70
Wilted 3 days ..	52.50	7.97	40.07	4.96
" 6 " ..	50.00	7.75	41.70	5.50
" 9 " ..	49.39	8.66	44.72	6.76
(5) Crude Fibre.				
1921.				
Freshly cut	29.09	3.91	29.94	3.73
Wilted 8 days ..	30.09	4.80	26.63	3.79
1922.				
Freshly cut	15.15	2.49	24.88	3.17
Wilted 3 days ..	18.35	2.79	27.15	3.35
" 6 " ..	21.62	3.34	28.81	3.79
" 9 " ..	23.85	4.17	25.22	3.81
(6) Ash.				
1921.				
Freshly cut	12.26	1.65	14.20	1.76
Wilted 8 days ..	12.14	1.94	15.40	2.19
1922.				
Freshly cut	14.66	2.41	14.17	1.81
Wilted 3 days ..	11.65	1.77	17.35	2.14
" 6 " ..	11.69	1.80	15.67	2.06
" 9 " ..	11.82	2.06	15.43	2.33

The somewhat misleading character of percentages, owing to the relationships discussed in the preceding paragraph, have to be particularly borne in mind in comparing the figures in Table IV for any given constituent before and after ensiling. Changes in composition in the silo involved decreases in protein, ether extract, and nitrogen-free extract, and increases in moisture, crude fibre, and ash.

All apparent gains must of course be relative rather than absolute. The table indicates that the losses in the silo are somewhat less in the case of wilted sunflowers, a conclusion which is emphasized in the next section of this paper.

Losses in the Silo

To estimate losses in the silo accurately is a somewhat difficult matter. In a small experimental silo, such as those used in the present work, a disproportionately large quantity of silage is lost by spoilage at the top. Screens consisting of a single thickness of loose sacking have always been inserted about a foot from the surface at the time of filling, in an effort to separate the material which is subject to normal fermentation from that which is likely to spoil owing to the access of air, but it has proved difficult to get a clear-cut separation of this sort. On the other hand the loss by drainage in these small silos is much less than in a large farm silo where heavy pressures are developed. The common method of enclosing weighed samples of fresh material in sacks and burying these in a silo at the time of filling, for recovery and analysis when the silage is being taken out, is reasonably accurate only when a number of sacks are buried at different depths, to compensate for the downwash of soluble materials.

In Table V, another method has been used to arrive at an estimate of losses in the silo. This table is derived from Table IV, by assuming that no loss has occurred in the crude fibre, or in other words that it has remained constant in absolute quantity, and that its increased percentage after ensiling must bear a definite ratio to the losses in other constituents. Russell (8) concluded, as a result of five seasons' work, that practically no change occurred in the fibre of maize during ensilage.

TABLE V.—LOSSES IN SILAGE FROM FRESH AND WILTED SUNFLOWERS.

(Calculated on the assumption that crude fibre remains constant.)

	Dry Matter	Crude Protein	Ether Extract	N-free Extract	Ash	Crude Fibre
A.—Weights of each constituent in 100 lb. dry matter at time of filling silos. 1922.						
Freshly cut	100.00	18.1	2.7	49.4	14.7	15.1
Wilted 3 days	100.00	14.4	3.1	52.5	11.7	18.3
" 6 "	100.00	13.5	3.2	50.0	11.7	21.6
" 9 "	100.00	12.1	2.9	49.4	11.8	23.8
B.—Corresponding weights remaining after ensiling.						
Freshly cut	60.9	8.1	1.8	27.3	8.6	15.1
Wilted 3 days	67.6	9.1	1.3	27.1	11.7	18.4
" 6 "	75.0	8.8	1.5	31.3	11.8	21.6
" 9 "	94.6	11.6	2.3	42.3	14.6	23.8
C.—Percent loss in the silo (*)						
Freshly cut	39.1	55.3	34.2	44.8	41.2	0.0
Wilted 3 days	32.4	36.5	58.7	48.4	+ 0.6	0.0
" 6 "	25.0	34.3	52.8	37.4	+ 0.6	0.0
" 9 "	5.4	4.7	21.4	14.4	+23.4	0.0

* The *plus* signs denote apparent gains.

That such an assumption is not strictly valid in the present work is shown by the fact that in some cases it involves an apparent increase in the absolute quantities of ash and moisture. The losses shown in Table V must therefore be considered as minimal, since to the same extent as losses in crude fibre have been neglected would the losses in other constituents have been greater than those recorded. Only the series of 1922, in which conditions were better controlled, has been used in this table. As mentioned previously, exposure to rainfall was a complicating factor in 1921, making the results difficult of interpretation.

The most striking features which the table brings out are the serious magnitude of the losses, especially in protein and nitrogen-free extract, and the fact that losses in the silo fall off rapidly with length of previous wilting. The heavy losses during wilting are thus in a measure compensated by the smaller losses in the silo. There would probably be less drainage loss from the wilted sunflowers, but it is also possible that the fermentation losses were less because of the disappearance during the wilting of the most readily fermentable (and digestible) constituents. The latter method of reducing fermentation losses is of doubtful merit.

Summary of Losses During Wilting and in the Silo

In Table VI is brought together a summary of the losses during wilting and in the silo, derived from Tables II and V. The apparent absolute gains of moisture and ash in the silo (Table VI, B) must be due, as has been explained, to some destruction of crude fibre, which has been neglected in the method of calculation used. However, the sudden break in the curve between the figures for 6 days wilt and 9 days wilt (for losses in the silo) must result from some abnormal destruction of fibre, or error in sampling the silage, in the latter case. The actual analyses of the dried, ground silage were repeated and found to be correct. Consequently the figures for the 9-day wilt in sections B, C, and D of the table must be discounted. Nevertheless, the figures for fresh sunflowers, and the 3- and 6-day wilts, are sufficient to show quite clearly the general magnitude and trend of the losses.

The relative gain in moisture content in the silo (see Table IV) involves the result that losses will be greater numerically when reported as a percentage of the dry matter than when reported as a percentage of the green weight of sunflowers. This explains the relationship of the first three columns of figures in Table VI, D.

The losses during wilting increase with length of exposure, but as already stated these are to some extent compensated by smaller losses from wilted material in the silo, so that the total loss by wilting and ensiling is only a little greater in the wilted

TABLE VI.—SUMMARY OF LOSSES PER 100 POUNDS FRESH SUNFLOWERS.*

	Total	Moisture	Dry Matter	Crude Protein	Ether Extract	N-free Extract	Ash	Crude Fibre
A.—Weight of each constituent lost during wilting.								
1922.								
Freshly cut	—	—	—	—	—	—	—	—
Wilted 3 days ...	7.24	4.88	2.37	0.95	0.02	0.72	0.77	+0.09
" 6 " ...	15.28	11.93	3.35	1.21	0.03	1.54	0.89	+0.32
" 9 " ...	27.70	23.90	3.81	1.45	0.09	1.87	0.92	+0.52
B.—Weight of each constituent lost in the silo.								
Freshly cut	21.4	14.9	6.4	1.6	0.15	3.6	0.99	0.0
Wilted 3 days ...	15.7	11.1	4.6	0.7	0.25	3.6	+0.10	0.0
" 6 " ...	10.0	6.7	3.3	0.6	0.22	2.5	+0.09	0.0
" 9 " ...	+6.9	+7.6	0.7	0.1	0.08	0.9	+0.35	0.0
C.—Total weight lost by wilting and ensiling.								
Freshly cut	21.4	14.9	6.4	1.6	0.15	3.6	0.99	0.0
Wilted 3 days ...	22.9	16.0	6.9	1.7	0.27	4.3	0.67	+0.09
" 6 " ...	25.3	18.7	6.6	1.8	0.25	4.0	0.80	+0.32
" 9 " ...	20.8	16.3	4.5	1.5	0.17	2.8	0.57	+0.52
D.—Percent lost by wilting and ensiling.								
Freshly cut	21.4	17.9	39.1	55.2	34.2	44.8	41.2	0.0
Wilted 3 days ...	22.9	19.1	42.2	56.9	60.4	52.9	27.9	+ 3.6
" 6 " ...	25.3	22.3	40.2	60.9	56.0	49.3	33.1	+12.8
" 9 " ...	20.8	19.5	27.3	51.2	37.1	34.0	23.7	+20.9

* The *plus* signs denote gains.

sunflowers. The marked increase in the percentage of crude fibre during wilting is, however, decidedly objectionable, and the loss of the readily fermentable carbohydrates before ensiling must be detrimental to the character of the fermentation. The preponderance of the evidence seems to be in favour of ensiling the sunflowers in the fresh condition, or only slightly wilted, but the magnitude of the losses by either method of handling (about 40 percent of the dry matter!) shows that neither method can be considered at all satisfactory.

Conclusions.

Apparently the losses incident to the ensiling of sunflowers cannot be reduced by wilting the material before filling the silo. Furthermore, it is undesirable to attempt to prevent drainage losses by the expedient of a water-tight silo, since an excessive moisture content usually means inferior silage. Another plan which some of our farmers have tried seems to be much more promising, namely, to ensile the sunflowers in the fresh condition, but mixing them in the cutting box with some dry material such as oat sheaves or straw.

Mr. W. D. Albright, superintendent of the Experimental Station, Beaverlodge, Alberta, kindly sent us a sample of silage made in this way, and furnished the following particulars:—

About three tons of barley, three tons of oats and two tons of wheat, all thoroughly cured in the shock, were hauled to the silo and stacked there in advance of filling. About thirty-two tons of green sunflowers were mixed with the cured cereals at filling. First of all, a couple of loads of barley were cut up and blown into the bottom, then the third load of barley was mixed with some sunflowers. Not until the barley was all through did a man go in to tramp, because of the beards. The oats and sunflowers were then run in, and finally the wheat-sunflower mixture, finishing with several loads of sunflowers alone. Two men were in the silo tramping towards the last, though a distributor pipe was used. A little water was run in, but it is probable that this was a mistake, for some juice exuded through the cracks between the staves, estimated roughly to be about equal in quantity to the water put in.

The sample which Mr. Albright forwarded was taken from the wheat-sunflower mixture. It was enclosed in a tin container, and reached the laboratory apparently in perfect condition. Its appearance and odour showed it at once to be first quality silage, a judgment which is fully borne out by the following analysis:

Moisture	69.20%
Total acid	0.855%
Non-volatile acid as lactic	0.527%
Volatile acid as acetic	0.328%
Ratio non-volatile to volatile acid	1:0.62
Amino nitrogen as crude protein	0.416%
Water-soluble N as crude protein	0.992%
Total nitrogen as crude protein	2.695%
Ratio water-soluble to total N	1:2.72%
Volatile base as ammonia	0.020%

The nature of the ratios of non-volatile acid to volatile acid, and of water-soluble nitrogen to total nitrogen, indicates the fermentation to have been of a highly desirable type, with a minimum amount of protein-splitting and wastage. The same is shown by the negligibly small content of volatile base. This last determination was not used in our earlier silage work, but has been added to our list of tests for quality, as it appears to be a quite sensitive indicator of spoilage. The volatile base is distilled from the juice or water extract, in the presence of excess magnesium oxide.

The results of our examination of the wheat-sunflower silage from Beaverlodge are such as to lead us to support Mr. Albright in his conclusion that "Four years' experience strongly commends to me the practice of ensiling fresh-cut sunflowers with cured cereals where the height of the silo permits sufficient pressure to ensure proper packing and curing."

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Report of the Summer Fallow Substitute Section Committee on Field Experimentation.*

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At the annual meeting at Winnipeg held in December, 1921, a paper was presented, pointing out the vital need for discovery of practical summer fallow substitutes which could be grown on a scale sufficiently large to balance other crops in a suitable rotation of crops, to permit the development of a permanent system of agriculture and to avoid the outstanding evils of the present system of cropping; namely, soil drifting, high production costs, lack of continuity of income, uneven distribution of labour and dangers incident to too rank a vegetative growth the year following summer fallow. Experiments that had been carried on to date were briefly reviewed and a suggestion was made that a committee consisting of the superintendents of experimental farms and their assistants and the professors of field husbandry and their assistants there present, be appointed for the purpose of devising a uniform project to be conducted in a similar manner at all stations in the prairie provinces which would determine the possibility of growing various crops in rows as fallow substitutes and eventually lead to the solution of the problem.

This suggestion was accepted and the writer was appointed chairman of a committee to be known as the Fallow Substitutes Committee. As a result of this a project was worked out and it was agreed at the first meeting of the committee to follow this project as closely as local circumstances permitted. The project as originally drawn was as follows:—

SUMMER FALLOW SUBSTITUTES

OBJECT:—

To determine,—

1. The yield of various cultivated crops.
2. The yield of wheat following or alternating with each cultivated crop as compared to the yield of wheat on fallow.

Field Plan,—

Each block shall be divided into 21 plots each 15.5 feet in width with 3.5 feet division strips or alleys. Each plot will consist of 32 drill rows of wheat or five rows of the crop used as a fallow substitute. These crops will be planted so that the distance from centre to centre will be 42 inches in each case.

Procedure,—

When seeding, begin at west side of plot and work east. The alleys between plots will necessarily differ somewhat in the row seedings.

Seed one block as follows in 1922:

1 Oats in double rows 36 inches apart.
2 Oats in triple rows 30 inches apart.
3 Barley in double rows 36 inches apart.
4 Barley in triple rows 30 inches apart.
5 Wheat in double rows 36 inches apart.
6 Wheat in triple rows 30 inches apart.
7 Corn in single rows 42 inches apart.
8 Potatoes in single rows 42 inches apart.
9 Sunflowers in single rows 42 inches apart.
10 Summer fallow.
11 Sudan Grass in double rows 36 inches apart.

Seed a complete duplicate series.

Seed another block to Marquis wheat in separate plots of 32 drill rows each (0.05 acre) with alleys of 3.5 feet.

In 1923 seed first block to wheat and second block to fallow substitutes as outlined above. Continue alternating the two blocks during the life of the experiment.

Cultivation should be sufficient to keep all plots free from weeds. Dates and kind of cultivation should be recorded in the annual reports.

* Presented at the Annual Meeting of the Western Canadian Society of Agronomy, Edmonton, Alberta, December 29, 1923.

In December 1922, at the annual meeting of this society, at Saskatoon, the results of the first year's work were presented in summary form and a recommendation was made that the Fallow Substitutes Committee be merged with the Committee on Field Experimentation. This recommendation was adopted so that the present report becomes a part of the report of that committee. At the request of the chairman, Mr. M. J. Tinline, the writer assumed responsibility for assembling the data for presentation this year.

Acknowledgements.

In presenting this report we wish to make acknowledgement of the valuable assistance rendered by E. G. Booth, Director of Co-operative Experiments, Field Husbandry Department, University of Saskatchewan, who assembled the data from the various experimental farms and from co-operating members of the Saskatchewan Field Husbandry Association. We also wish to acknowledge the valuable co-operation received from those who have conducted the work on the various experimental fields including:—

G. H. Cutler, Prof. of Field Husbandry, University of Alberta, Edmonton.

J. H. Ellis, Experimentalist in Field Husbandry, Manitoba Agricultural College, Winnipeg.

T. J. Harrison, Prof. of Field Husbandry, Manitoba Agricultural College, Winnipeg.

W. C. McKillican, Supt. Experimental Farm, Brandon, Man.

N. D. MacKenzie, Supt. Experimental Farm, Indian Head, Sask.

W. A. Munro, Supt. Experimental Farm, Rosthern, Sask.

T. M. Stevenson, Field Supt., Field Husbandry Department, University of Saskatchewan, Saskatoon.

S. J. Sigfussen, Assistant Supt., Experimental Farm, Brandon, Man.

J. G. Taggart, Supt. Experimental Farm, Swift Current, Sask.

M. J. Tinline, Supt. Experimental Farm, Scott, Sask.

Discussion of Results.

The yields are given in bushels per acre for the grain and potato crops and in tons per acre of green weight for the forage crops. These results are tabulated and appended hereto. The five stations in Saskatchewan and that at Brandon have conducted the project as outlined with some minor variations. At Edmonton and Winnipeg, the project is modified to meet local conditions. No data are available as yet from the Lacombe, Lethbridge and Beaverlodge Stations, through some work on this problem is in progress at those points. In addition to the yield tables, a combined table has been prepared in which the two years' crops on the same land have been reduced to a common denominator expressed in dollars and cents. The values used are arbitrary and uniform for each station, for the sake of ready comparison.

Recommendations for Continuation of Project.

It seems clear that we are making progress in the solution of this problem. The results presented here demonstrate the value of co-operation in certain types of experimental work. Having a set of results that can be assembled and tabulated for direct comparison is of great value to the teacher and the research student.

In order not to confuse the issue or to make the experiment too difficult it was thought best to limit the standard project to determination of yields. There are additional data, however, that might well be gathered in connection with this project. It is therefore recommended, that wherever possible, a part or all of the following data be taken.

1. Date of maturity of the row crops of grain and of the succeeding wheat crop, in comparison with the same varieties sown by the ordinary methods on summer fallow and on second crop land.
2. Disease infestation of the rows and the succeeding crops of wheat in comparison with the same varieties on fallow and second crop land.
3. Quality of grain grown in rows and of the succeeding crop of wheat as determined by physical tests.
4. Quality of grain grown in rows and the succeeding crop of wheat as determined by physical tests.
5. A study of the soil moisture on the several plots in the experiment.

It is probable that all of these things cannot be done at all stations and it would be

an imposition to ask any one department or institution to assemble and tabulate all the data thus obtained. But by making a more complete study of the things incidental to this problem we would, without increasing the field work at any station, be able to develop a fuller knowledge of the subject as it applies to conditions surrounding each station.

It seems best that the uniform part of the project be confined to yield data in the future as heretofore.

It is recommended that other stations add the project when conditions permit in order to make the resulting data still more comprehensive.

Conclusion.

The practical benefit to Western Canada resulting from this experiment is already very gratifying. Thousands of acres have been sown to row crops and this has been a stimulus to the development of good crop rotations. Along with the increase in row crops has come an increased demand for sweet clover seed. This shows that farmers have not lost sight of the other vital factor in a good rotation.

The tabulated results speak for themselves.

TABULATED APPENDIX TO REPORT OF SUMMER FALLOW SUBSTITUTES SECTION, COMMITTEE OF FIELD EXPERIMENTATION, WESTERN CANADIAN SOCIEY OF AGRONOMY.

TABLE I.

Yield in Bushels per Acre of Grain Crops Grown in Rows at Several Stations.

Crop grown	Saskatoon			Brandon		Indian Head	Rosthern		Scott		Swift Current	
	1921	1922	1923	1922	1923	1923	1922	1923	1922	1923	1922	19
Oats in 2 R. groups	59.6	52.1	85.6	85.9	61.7	40.0	55.6	33.5	29.4	61.5	50.6	47
Oats in 3 R. groups	63.9	56.2	94.7	87.0	78.3	42.5	53.0	32.9	26.6	75.0	58.8	53
Barley in 2 R. groups	39.2	36.9	50.4	N.R.	42.0	8.1	25.8	21.6	7.6	35.6	21.2	9
Barley in 3 R. groups	49.4	39.4	57.7	N.R.	N.R.	5.2	24.8	28.6	13.5	40.2	N.R.	N.I
Wheat in 2 R. groups	18.5	24.2	32.7	32.3	13.2	12.8	20.8	16.5	9.3	23.2	18.7	8
Wheat in 3 R. groups	22.1	25.0	32.2	36.7	14.1	10.0	24.0	21.7	10.8	30.2	21.3	N.I

Note:—Average yields 1921-23 Winnipeg were reported as 32.3 for oats and 11.3 for wheat in three ro groups. Yields at Edmonton were reported for wheat only as follows: wheat in two row group 1921—40.6, 1922—8.1, 1923—35.9; wheat in three row groups, 1921—43, 1922—10.9, 1923—43. The letters N.R. in table mean no report received.

TABLE II.

Yields in tons of green weight per acre for forage crops grown as fallow substitutes, all in single rows, except Sudan grass which is in double rows. The yields are figured to the nearest tenth of a ton, smaller fractions being disregarded. Yields of potatoes are in bushels per acre.

Crop grown	Saskatoon		Indian Head	Brandon		Rosthern		Scott		Swift Current	
	1922	1923	1923	1922	1923	1922	1923	1922	1923	1922	1923
Corn	9.2	9.3	8.8	15.6	16.3	8.9	18.3	4.2	5.9	7.3	9.4
Potatoes	165.0	263.8	90.0	N.R.	N.R.	200.00	224.2	196.3	357.3	142.0	261.1
Sunflowers ...	16.5	12.7	12.4	30.3	28.7	8.9	10.8	9.9	13.9	9.2	16.7
Sudan Grass ..	2.2	3.4	N.R.	10.3	10.0	8.7	4.2	N.R.	N.R.	3.2	4.7

TABLE III.

Yields of wheat in bushels per acre following fallow and various fallow substitutes at several stations.

Fallow or fallow substitute preceding year	Saskatoon 1922	Saskatoon 1923	Indian Head 1923	Winnipeg Average 22 - 23	Brandon 1923	Rosthern 1923	Scott 1923	Swift Current 1923
Fallow	18.9	56.2	22.0	32.7	25.3	23.9	37.0	20.2
Corn single rows	N.R.	54.5	23.7	28.8	22.3	26.5	47.2	12.6
Potatoes, single row	N.R.	52.7	21.3	N.R.	N.R.	26.4	40.8	21.5
Sunflowers, single rows	N.R.	52.0	20.2	N.R.	19.3	22.5	41.3	17.0
Sudan Grass, double rows	N.R.	55.0	N.R.	21.3	24.0	25.8	N.R.	11.0
Oats, double rows	27.4	49.3	18.5	N.R.	19.3	18.2	48.8	9.9
Barley, double rows	22.5	52.4	20.8	N.R.	N.R.	17.9	47.8	12.9
Wheat, double rows	23.1	57.0	17.8	N.R.	24.0	19.8	41.2	8.4
Oats, triple rows	26.3	46.2	17.5	28.5	24.3	18.3	50.5	8.4
Barley, triple rows	23.7	43.3	18.5	N.R.	N.R.	18.5	42.5	N.R.
Wheat, triple rows	25.1	45.5	15.5	26.0	23.0	21.7	41.0	10.0

Note:—Edmonton reports wheat in bushels per acre following wheat in double rows for 1922 and 1923 respectively as 9.3 and 49.5, and following wheat in triple rows 10.2 and 50.6. No report was received for wheat on fallow in 1922 but in 1923 the yield was 47.8.
N.R. means no report or no record.

TABLE IV.

A selection of data from Table III for more convenient comparison showing the yields of wheat in bushels per acre obtained at several stations in 1923 after fallow and fallow substitutes.

Fallow or fallow subsitutes preceding year.	Saskatoon	Indian Head	Brandon	Rosthern	Scott	Swift Current
Fallow	56.2	22.0	25.3	23.9	37.0	20.2
Corn, single row s	54.5	23.7	22.3	26.5	47.2	12.6
Sunflowers, single rows	52.0	20.2	19.3	22.5	41.3	17.0
Oats, double rows	49.3	18.5	19.3	18.2	48.8	9.9
Wheat, double rows	57.0	17.8	24.0	19.8	47.8	8.4
Oats, triple rows	46.2	17.5	24.3	18.3	50.5	8.4
Wheat, triple rows	45.5	15.5	23.0	21.7	41.0	10.0

TABLE V.

Yields in loads of sheaves per acre obtained by growing oats in rows as a fallow substitute in Saskatchewan in 1923 as repored by members of Saskatchewan Field Husbandry Association. *

Post Office Address	Loads per Acre	Remarks by Co-operator
Spalding	1.00	Satisfied
Macrorie	.33	Satisfied
Laura	1.00	Easier to handle than corn.
Rosetown	1.35	Stopped soil drifting.
Druid	1.25	Stood up while close drilled lodged.
Mankota	2.00	Well satisfied.
Watrous	1.00	No comment.
Glidden	3.00	Crop stood up well.
Kindersley	1.00	No comment.
Stalwart	1.00	Great success, prefer two rows.
Tuxford	0.67	Must be sowed early.
Laura	1.33	No comment.
Alameda	Heavy	Rust caught the late seeding.
Summerberry	1.00	Great success but seeded too late.
Archive	0.20	Thoroughly satisfied after 3 years' trial.
Plunkett	1.50	Splendid crop but weedy.
Bresaylor	2.00	No comment.
Dinsmore	1.00	No weeds, advise using fall plowing.
Belbeck	1.00	Rusted badly—part drowned out lowered yield.
Kindersley	1.00	Row crop yielded about as much as close drilled.

* It is estimated that there are about 300 sheaves per load.

TABLE VI.

Yields of wheat in bushels per acre grown after a cereal crop used as a fallow substiute in co-operative experiments in Saskatchewan as reported by members of the Saskatchewan Field Husbandry Association, 1923.

Farm Location	On row land	On fallow	Remarks.
Shackleton	26	30	Land does not drift.
Rosetown	38	35	No drifting.
Alameda	20	15	No drifting, less rust, better grade.
Archive	30	30	17% dockage but thoroughly satisfied.
Wilkie			Too fiddling.
Spalding	23.5	26.4	Likes practise.
Maryfield	14	19	Troubled with volunteer oats.

TABLE VII.

Estimated value per acre of crops for two years 1922-23 at several stations. Arbitrary values were assigned in order to facilitatate ready comparison of results.

Crop	Saskatoon	Brandon	Rosthern	Scott	Swift Current
Fallow	$ 44.96	$ 20.24	$ 19.12	$ 29.60	$16.16
Corn	71.20	64.64	47.90	50.36	31.98
Potatoes	108.16	N.R.	101.12	111.16	74.00
Sunflowers	91.10	106.34	44.70	61.74	41.20
Sudan	52.80	60.40	55.44	N.R.	21.60
Oats 2 rows	50.07	41.21	31.24	47.86	23.10
Barley 2 rows	56.68	N.R.	24.64	41.28	18.80
Wheat 2 rows	64.96	45.04	32.48	40.40	21.68
Oats 3 rows	53.82	45.54	30.54	48.38	24.36
Barley 3 rows	50.40	N.R.	24.72	39.40	N.R.
Wheat 3 rows	56.40	47.76	36.56	41.44	25.04

The above returns per acre were computed by using the following values:—

Wheat	$0.80 per bus.	Corn silage	$3.00 per ton green weight
Oats	0.30 " "	Sunflower silage	3.00 per ton green weight
Barley	0.40 " "	Sudan grass	4.00 per ton green weight
Potatoes	0.40 " "		

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